DOCUMENT RESUME

ED 265 020 SE 046 320

AUTHOR	Housel, David C.; Housel, Doreen K. M.
TITLE	Come Fly with Me! Exploring Science K-6 through Aviation/Aerospace Concepts.
INSTITUTION	Aerospace Education Council of Michigan, Lansing.; Michigan Aeronautics Commission, Lansing.
PUB DATE	83
NOTE	307p.; For the manual for grades 7-9, see SE 046 321.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC13 Plus Postage.
DESCRIPTORS	*Aerospace Education; Elementary Education; *Elementary School Science; Futures (of Society); Navigation; Resource Materials; *Science Activities; Science Education; *Science Instruction; *Space Exploration; *Space Sciences; Weather
IDENTIFIERS	*Aviation Education

ABSTRACT

This guide contains 95 activities dealing with various aerospace/aviation education concepts. The activities are presented in units for kindergarten through sixth grade organized around a central theme at each grade level. The themes follow a sequence from grade to grade. Beginning with the introduction of basic inquiry process skills in kindergarten, the guide moves through progressively more complex activities dealing with theory of flight, flight in the atmosphere, the earth from space, the exploration of the solar system, and culminates at the sixth-grade level, with activities on futurism and living in space. Each activity includes information on the subject area, grade level, group size, time required, teaching strategy, type of activity, concept(s) fostered, and skills fostered. Each activity also contains objective(s), materials needed, teacher background information, instructional strategies, suggested extension activities, and number(s) corresponding to resources found in an appendix. These resources (numbered from 1-298) include films, student books, and other materials organized by topic area, as well as commercial textbooks. Other appendices contain addresses of publishers and government/non-government agencies, glossary, and an appendix of additional resources. The guide's conceptual framework and other general information are included in an introduction. (JN)

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Come FLY With Me!

EXPLORING SCIENCE K - 6
THROUGH AVIATION/AEROSPACE
CONCEPTS

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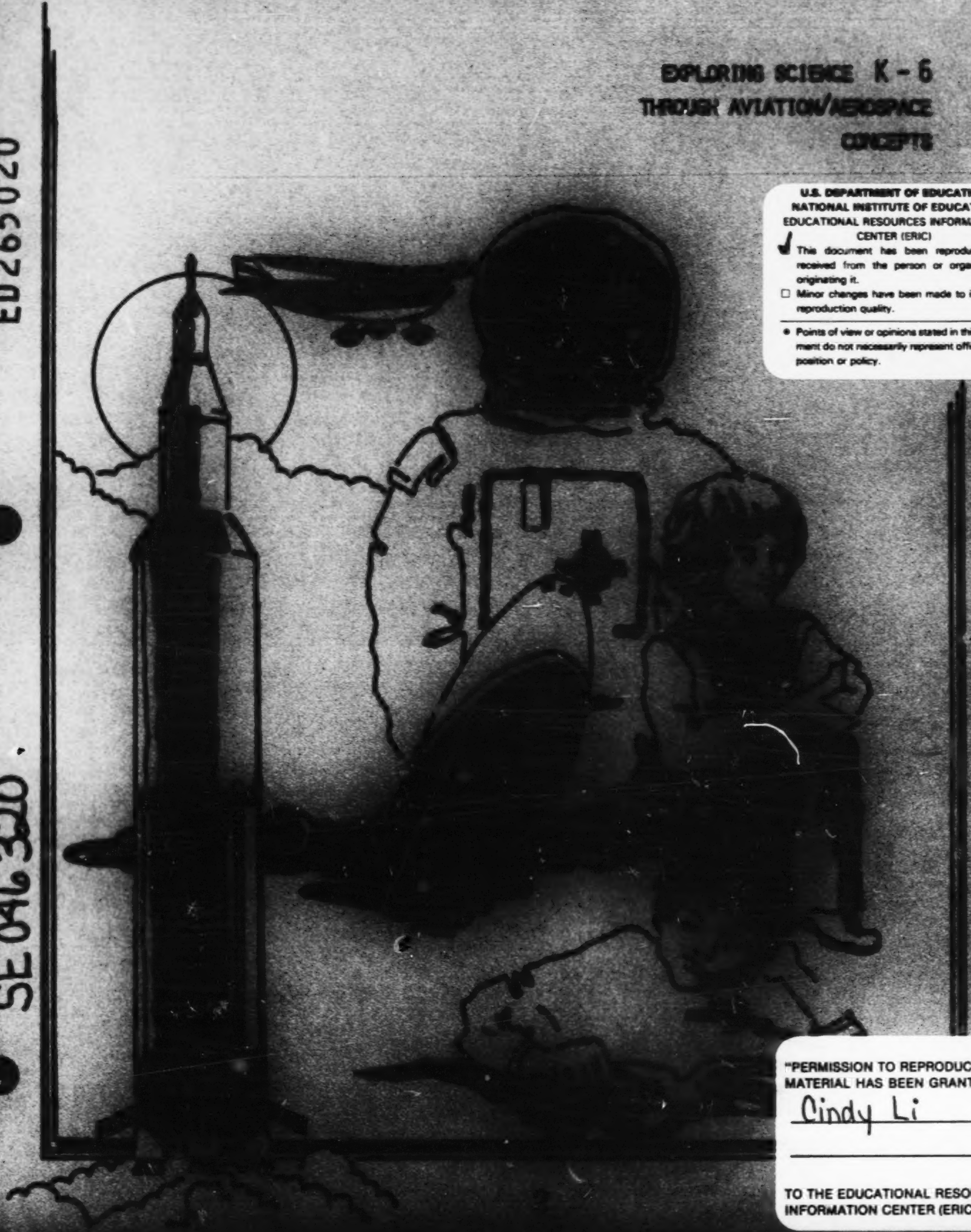

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Come FLY with me!

EXPLORING SCIENCE K-6 THROUGH AVIATION/AEROSPACE CONCEPTS

by

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&
DOREEN K.M. HOUSEL MA

MICHIGAN
AERONAUTICS COMMISSION
1983

COME FLY WITH ME!
Exploring Science K-6
Through
Aviation/Aerospace Concepts

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Lansing, Michigan

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The Aerospace Education Council of Michigan congratulates the authors of COME FLY WITH ME, Dr. and Mrs. David Housel. With professionalism and authority, they put in writing and graphics the aerospace education science concepts as outlined by this Council.

The completion of the Phase I Project, under the guidance and direction of the Council and particularly the curriculum committee of Harold Fisher, Wanda Jubb, James Sowle, and Mary Creason, marks the attainment of one of the Council's goals of providing motivating educational materials related to aviation and space.

Funds for the project were provided by the Michigan Department of Transportation, and support was given the authors by Oakland University.

Robert Paulson, Chairman

FORWARD

In an age of robot laboratories on Mars, satellite tours of the solar system and shuttle transportation systems, an important goal of education should be to prepare students to live in the society which created those technologies. More importantly, students should be given the skills and processes necessary to live in a future society where, certainly, aviation and space will continue to be an integral part of those students environment.

Basic processes children should gain which will enable them to deal with the future, are those which develop the critical, rational mind. Professional educators recognize the development of rational powers as a central goal in the education of children. They also recognize that science is one area of the curriculum, through the emphasis on inquiry and problem solving, which can achieve this goal.

Two prerequisites needed to achieve critical thinking skills are first, to provide motivating activities for students and second, to relate what those students are learning to real life situations. A curriculum which includes aerospace education achieves both the inclusion of motivating, high interest topics and material which is a part of everyday life.

As Dean of the School of Human and Educational Services at Oakland University, I wish to congratulate the Michigan Aeronautics Commission for providing the teachers and children of Michigan an Aerospace Education Guide for use in the science classroom which capitalizes not only on the serious concepts of aviation and space but also on the creative, joyful nature inherent in exploring aviation/aerospace topics.

Dr. Gerald J. Pine, Dean
Gerald J Pine
School of Human and Educational
Services, Oakland University
Rochester, Michigan

1957

PREFACE

STATE OF MICHIGAN

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TO FLY has been the dream of mankind since the beginning of time. To FLY is the dream of each child upon discovering the beauty and freedom of soaring birds. TO FLY is to experience beauty, truth, and peace. We believe each child is entitled to explore the vast sky above us; to identify with man's explorations in air and space. He can lift from the earth with the aeronauts in the first manned balloon flight in Paris, November 21, 1793; relive the famous flight of the Wright Brothers at Kitty Hawk, December 17, 1903; be propelled into space in the Mercury, Gemini, Apollo, and Skylab vehicles; yes, he can dream of a future home in space.

We offer COME FLY WITH ME as a vehicle to allow the teacher to assume the role of explorer along with the students when using the sky as a classroom; to teach science through the environments of air and space.

COME FLY WITH ME, Exploring Science K-6, is a project of the Aerospace Education Council of Michigan, a volunteer organization of educators serving the Michigan Aeronautics Commission. Cooperation of the Department of Education has been through representation on the Council.

The Commission is grateful to Oakland University which has been supportive of the authors' endeavors in writing the book, in teacher workshops, in the extensive classroom field-testing, and in the post-pilot program revisions.

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ACKNOWLEDGEMENTS

A grateful acknowledgment is made to all who helped with the production of this guide. A special thanks is extended to the following:

To the Michigan Aerospace Education Council for their guidance and support and especially to Mary Creason for her continued encouragement.

To Dr. John Bergeson of the I.M.C. at Central Michigan University for making available to us many Aerospace Education materials.

To Dr. Don Miller of the School of Human and Educational Services at Oakland University for support which made possible the field testing of this guide.

To the many teachers who field tested the guide with special thanks to the following educators whose written comments were valuable to the preparation of the final version of this guide...

Edna DeVitt, Livonia; Ruth Eiseman, Kalamazoo; Irma Gelhausen, Lapeer; Barbara Goodwin, Climax; Ed Hasenleder, Saginaw; William Hunter, Huron Valley; Judy Kestenholtz, Lansing; Carol King, Adrian; Natalie Kreeger, Fowlerville; Edward Longenecker, Hancock; Kay Rasmussen, Central Montcalm; Dick Smelser, Walled Lake; Steve Strait, Central Montcalm; David and Jane Thocher, Hart.

David and Doreen Housel
Northville, Michigan
August, 1983

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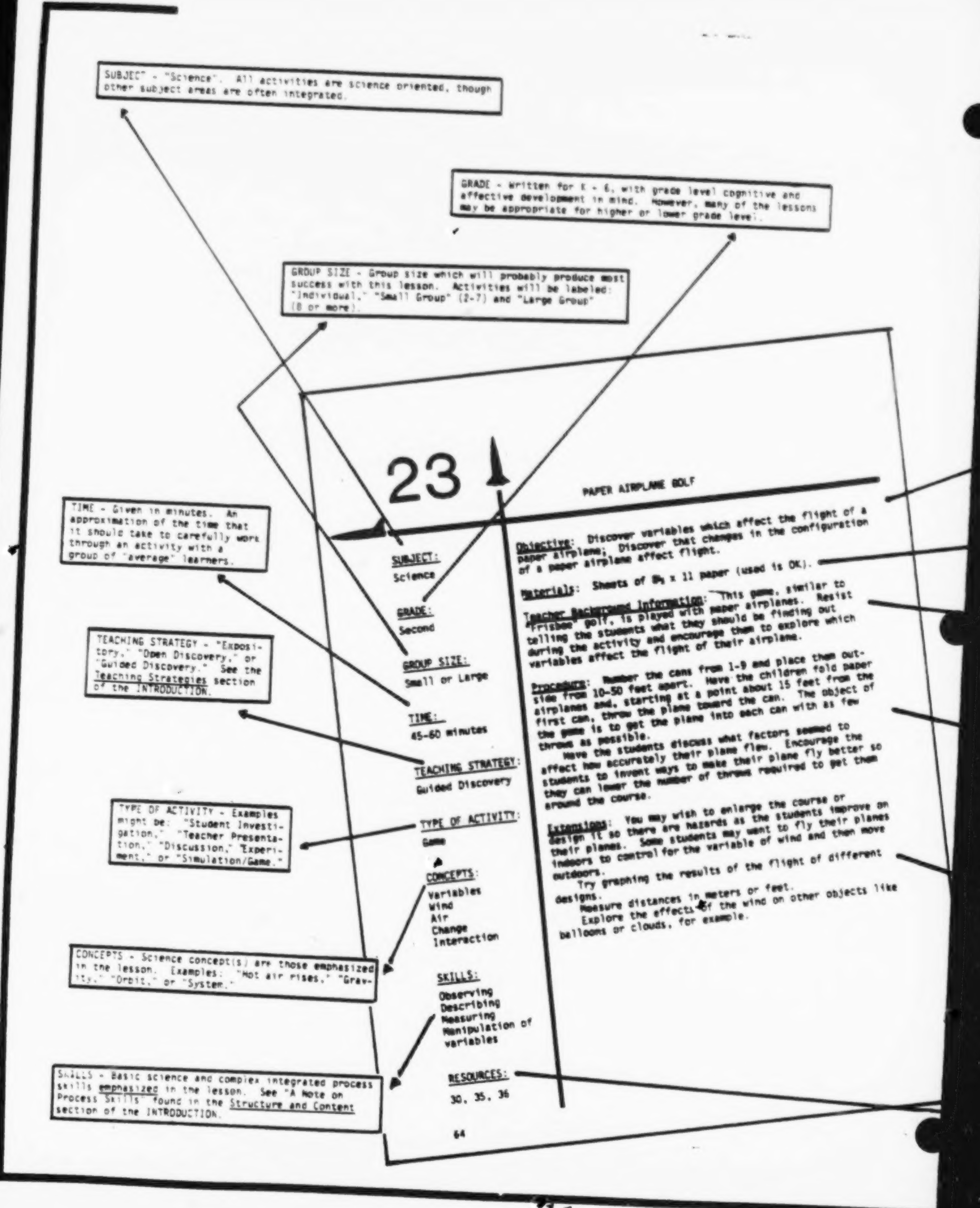

SUBJECT - "Science". All activities are science oriented, though other subject areas are often integrated.

GRADE - Written for K - 6, with grade level cognitive and affective development in mind. However, many of the lessons may be appropriate for higher or lower grade level.

GROUP SIZE - Group size which will probably produce most success with this lesson. Activities will be labeled: "Individual," "Small Group" (2-7) and "Large Group" (8 or more).

TIME - Given in minutes. An approximation of the time that it should take to carefully work through an activity with a group of "average" learners.

TEACHING STRATEGY - "Expository," "Open Discovery," or "Guided Discovery." See the Teaching Strategies section of the INTRODUCTION.

TYPE OF ACTIVITY - Examples might be: "Student Investigation," "Teacher Presentation," "Discussion," "Experiment," or "Simulation/Game."

CONCEPTS - Science concept(s) are those emphasized in the lesson. Examples: "Hot air rises," "Gravity," "Orbit," or "System."

SKILLS - Basic science and complex integrated process skills emphasized in the lesson. See "A Note on Process Skills" found in the Structure and Content section of the INTRODUCTION.

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PAPER AIRPLANE GOLF

SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Small or Large

TIME:
45-60 minutes

TEACHING STRATEGY:
Guided Discovery

TYPE OF ACTIVITY:
Game

CONCEPTS:
Variables
Wind
Air
Change
Interaction

SKILLS:
Observing
Describing
Measuring
Manipulation of variables

RESOURCES:
30, 35, 36

Objective: Discover variables which affect the flight of a paper airplane; Discover that changes in the configuration of a paper airplane affect flight.

Materials: Sheets of 8½ x 11 paper (used is OK).

Teacher Background Information: This game, similar to "Frisbee" golf, is played with paper airplanes. Resist telling the students what they should be finding out during the activity and encourage them to explore which variables affect the flight of their airplane.

Procedure: Number the cans from 1-9 and place them outside from 10-50 feet apart. Have the children fold paper airplanes and, starting at a point about 15 feet from the first can, throw the plane toward the can. The object of the game is to get the plane into each can with as few throws as possible.

Have the students discuss what factors seemed to affect how accurately their plane flew. Encourage the students to invent ways to make their plane fly better so they can lower the number of throws required to get them around the course.

Extensions: You may wish to enlarge the course or design it so there are hazards as the students improve on their planes. Some students may want to fly their planes indoors to control for the variable of wind and then move outdoors.

Try graphing the results of the flight of different designs.

Measure distances in meters or feet.

Explore the effects of the wind on other objects like balloons or clouds, for example.

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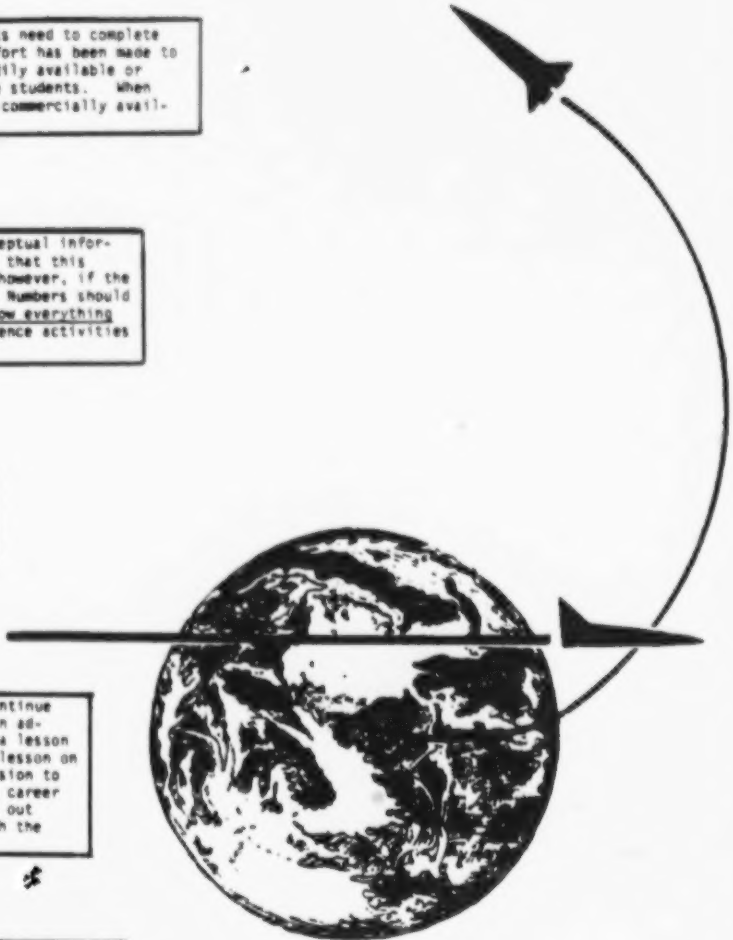
HOW TO USE THIS GUIDE

OBJECTIVES - Major cognitive and/or affective learnings expected of the students. Examples might be: "Student will know several ways to use a parachute," "Student will transcribe data to a chart," "Student will work as cooperative member of investigation team."

MATERIALS - Materials teacher and students need to complete the activity as written. A conscious effort has been made to include activites that use materials readily available or materials which can be constructed by the students. When activities may be enhanced by the use of commercially available materials, sources are listed.

TEACHER BACKGROUND INFORMATION - May be conceptual information or strategy information. It is hoped that this will be enough to get the activity started; however, if the teacher wants more information, the Resource Numbers should be of help. Remember, a teacher need not know everything before these activites and the notion of Science activities as feats of magic is NOT very helpful here.

PROCEDURE - How to initate the activity, a set of directions to follow and, where appropriate, suggestions for evaluation.



EXTENSIONS - Things to do that either continue an activity or modify it in some way. In addition, there will be shown ways to use a lesson in other curriculum areas. Example: A lesson on the space shuttle might suggest an extension to language arts with a poem about it or to career education with discussion on how to find out about the numbers of jobs associated with the shuttle.

RESOURCES - In the Appendices at the back of the Guide is a list of Resources, each of which has its own number. The numbers noted here correspond to the specific resource(s) related to each lesson.

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INTRODUCTION

CONCEPTUAL FRAMEWORK

From Daedalus, to da Vinci, to Montgolfier; from Lilienthal to the Wright Brothers, Lindbergh and Earhart; from Gagarin and Shepard to Armstrong and Lousma, human beings have dreamed of flight. That dream is now a powerful reality but what is important to education is what people have done to achieve that dream, not only that it has been done. It is the process of making dreams a reality, then, that is the business of education.

There is, in addition, an inate human quality which seems to demand that we ask, "What is so ?" and that we attempt to make sense out of things which seem not to make sense. Children come to us with that quality. However, even though the wish to inquire is inate, the ability to do so efficiently is learned and is properly and, we might even say, vitally, another responsibility of modern education.

Since this ability to inquire intelligently is so important and since science, by its very nature, specifically involves the whole process of inquiry, this Guide has been developed to assist you in your day to day attempt to provide students with what is meaningful and important to their growth, both in a cognitive and in an affective way.

There are a number of concepts that can be used to teach the inquiry process but perhaps none so highly visibly or highly motivational as the concepts of flying and of space travel. Children know of airplanes and rockets and space vehicles. These are not the stuff of farfetched dreamers any longer, but are realities in our lifetimes. How it all works, how they can become a part of it and what's going to happen next are some of the questions and concerns children already have. There is very little need to convince students that this is an exciting subject. Nor is it difficult for them to grasp how vital an understanding of aviation and space is to their futures.

Not only is aerospace education motivational but, as Robert Jones pointed out in an article on aerospace education, today's curriculums are,"....beset with 'negative' influences. (Though important parts of the curriculum) Drug education, environmental education, economic education....are in operation to combat negative societal factors. Aerospace education....can and should be a celebrative experience."[1] It was with that happy notion in mind that this curriculum was designed.

An Infusion Model

We would like you to know, too, that we are aware that when additional courses of study are added to an already crowded curriculum, somthing has to be set aside. The activities in this guide have been designed to be infused into an existing curricula, not to be added. A wealth of materials and resources have been available to Michigan teachers in aerospace education for some time so that teachers could integrate aviation and space concepts into their teaching. What has been missing is an organized group of ACTIVITIES which have clear objectives for each grade level, activities which are related to a theme that will fit easily into the existing goals of most teachers.

Goals

This guide provides some of those activities and has been written with the following overall goals in mind:

1) activities should provide students with experiences which will help them advance from basic concrete thinking skills to more advanced abstract thinking skills;
2) activities should provide students with information about aviation and aerospace and guide them to people and places where they can gather additional information;
3) activities should provide students with experiences which will not dull their natural curiosity but which will expand and enhance that curiosity.

Conceptual Themes

In addition to these goals, a number of important concepts tend to weave their way through the fabric of the guide. You will find, for example, that we feel children ought to understand the idea of interrelationship, the importance of the parts to the whole, not only in the systems and sub systems of "things" but in the interrelationships between people and things and between people and people.

---

1. Jones, R. Practices and dreams. In W. Matson (Ed.), The book of aerospace education. Washington, D.C.: American Society for Aerospace Education, 1978.

STRUCTURE and CONTENT

The guide consists of units for kindergarten through sixth grade organized around a central theme at each grade level.

The themes follow a sequence from grade to grade. Beginning with the introduction of basic inquiry process skills in kindergarten, the guide moves through succeedingly more complex activities dealing with theory of flight, flight in the atmosphere, the Earth from Space, the exploration of the Solar System, and culminates, at the sixth grade, with units on futurism and living in space.

A Note on Process Skills:

The process skills of science are the skills necessary for effective inquiry and are used by children to gather information, thus enabling them to build concepts about the world in which they live. Through this skill development, children build proficiency in gathering and evaluating information while learning concepts and generalizing about what they learn.

Once a skill level has been developed, it can be used as needed as the child experiences new activities. These skills will continue to be emphasized at succeeding grade levels, but in increasingly more complex situations. This strengthens children's abilities to apply the skill and helps them develop readiness for the more complex process skills. Just as development from simple to complex is evident in skill sequence, skill interrelatedness is evident in scope. A particular activity in these aerospace lessons will frequently serve for development of more than one process skill.

There is a focus on change and adaptability in the activities of the guide. It is important that students understand that there are forces in the environment which act on things and that they can change many of those forces. In so doing, they can change their environment or, equally important, the students can change themselves and adapt to their environment.

Another notion fostered throughout the activities is that science skills are life and life-time skills and that science and social science skills are the core of the art of discovering about life. Other skills measure life or they may describe life, but the sciences are life. There should be little difficulty then, in relating these activities to the rest of the teacher's curriculum and, through the EXTENSIONS, some ways to do this are suggested.

Finally, it is important that children develop a sense of appreciation for the benefits of exploration. We mean here an appreciation for the process of searching for answers and the products of that search. Appreciation can only come when one truly knows a thing in both a cognitive and in an affective way; exploration allows us that knowledge and thereby fosters that appreciation.

The definitions for the process skills are given in the following:

Observing. Using the senses to gather data from one's environment.

Ordering. Placing objects, ideas or events in a logical series based on their characteristics.

Classifying. Placing objects, ideas or event in categories based on their characteristics.

Data collection and recording. Systematic methods of recording and displaying information concerning the environment.

Measuring. Using a system of references and standards in order to determine quantitative characteristics of objects or events.

Inferring. Interpreting data.

Predicting. Forecasting of phenomena based on observation and inference.

Experimenting. Conducting investigations in a scientific manner in order to derive answers to specific questions.

Constructing and interpreting models. Representation of ideas.

Identification and control of variables. Identifying and manipulating parts of objects or events which, when changed, make a difference in how the object or event behaves.

Hypothesizing. Constructing questions which can be evaluated by observation, inference or experiment.

Sequence and Time Frame

The sequence and the choice of activities allows the teacher flexibility in the time of year the units are begun and also provides for the use of lessons from lower levels to be used as review for higher level grades. The activities and sequence also allow a teacher to use lower level activities, for students without prior aerospace education, to cover concepts not previously learned. In addition, the lessons are designed to fit into an existing curriculum which already includes process learning skills development or the activities may be used to provide process skills in a curriculum which has made little or no provision for their development.

The units are designed to be covered in the following time frames for each grade:

K - Two weeks
1 - Three weeks
2 - Three weeks
3 - Four weeks
4 - Four weeks
5 - Four weeks
6 - Four weeks

The specific concepts and process skills are detailed in each lesson throughout the Guide. The following is a synopsis of the important concepts and process skills found at each grade level.

Synopsis

Level K - OVER THE RAINBOW

Concepts and processes emphasized in this unit: color, shape, texture, sound, size, quantity, position, object.

The unit for kindergarten offers a wide variety of activities and experiences which emphasize process skills development. Most of the activities are designed to explore "What Flies?" Children learn to observe, discriminate, and describe, using objects and organisms in the classroom and outdoors. These experiences help them develop language and participation skills and contribute to their growing understanding of science process skills including observing, ordering, classifying, collecting and recording data using pictographs, measuring with non-standard units, inferring, and space/time relationships.

Level 1 - WAY UP HIGH

Concepts and processes emphasized in this unit: Force, wind, gravity, properties of air, systems, variables, evidence.

The children handle, observe and describe objects that fly. They learn that flying things are affected by the forces of wind and gravity and learn to describe evidence of these forces acting on objects. Students learn that objects can change and they learn that there are ways to recognize evidence of change. Observation and comparison lead to the concept of inference and prediction. As the children investigate the properties of various flying things they realize that most are systems of things working together to create something that can fly.

Level 2 - ABOVE THE CHIMNEY TOPS

Concepts and processes emphasized in this unit: interaction, sub systems, motion, evidence of interaction, energy and energy transfer.

The concept of energy transfer to create motion, as well as the concept that related objects or parts comprise the sub system of a system, are introduced. Students examine a variety of flying things including hot air balloons, paper and rubberband airplanes. The students' investigations of the parts of systems leads to the ability to develop operational definitions. The airport and its working as a system is explored.

Level 3 - BIRDS FLY - WHY CAN'T I?

Concepts and processes emphasized in this unit: Lift, drag, thrust, gravity, action-reaction, variables and control of variables.

Travel within the atmosphere is explored and students are introduced to the theory of flight including Bernoulli's principle. The concept of power for aircraft is introduced through activities dealing with propellers, jets and rockets. The effects of weather as a force which acts on aircraft are explored and the effects of the control surfaces on an aircraft are further investigated.

Level 4 - SOMEDAY I'LL WISH UPON A STAR

Concepts and processes emphasized in this unit: relative position, relative motion, polar coordinates, grids and coordinates, solar system.

The ideas and techniques developed in this unit are related to concepts of astronomy and space science. The concepts of coordinates are used to explore Landsat satellite photographs as well as false-color imagery. Students see that reference to different objects and coordinate systems leads to different descriptions of position and motion. Children also learn to use a variety of models to describe both the position and the motion of objects in the solar system and on earth.

Level 5 - WHERE THE CLOUDS ARE FAR BEHIND

Concepts and processes emphasized in this unit: exploration, evidence, inference, interpreting data, weightlessness, orbit, atmospheric pressure, magnetic field.

The primary focus of this unit is an inquiry into the needs of humans flying in space especially related to their physical environment. Children's investigations into the findings of solar system exploration by astronauts and robot satellites are used to foster an understanding of the temporariness of scientific information and the role of accurate observation and interpretation of data in inquiry.

Level 6 - DREAMS THAT YOU DARE TO DREAM.

Concepts and processes emphasized in this unit: Reduced gravity, waste management, heat, relativity, hyper speed, futurizing, scientific theory, hypothesizing.

The children explore the needs of humans living in space and form their own theories as to the future of space travel, space stations and the colonization of the other planets. Investigation of the Space Shuttle flights leads to a better understanding of the benefits of space exploration and the role of problem solving in scientific investigation.

HELPING KIDS LEARN

In building an aerospace guide, there ought to be a rationale for the selection and grade placement of subject matter. Part of the rationale for this Guide is derived from what science and aerospace educators deem important to aerospace science concept development. These concepts have been considered and have been ordered in terms of difficulty: Things that fly; Air and its properties; Weather and flying; Facts of flight; Airplanes, jets and rockets; Spacecraft; The Solar System; Humans traveling in space; Humans living in space.

In addition, part of the rationale is derived from what we know about how children learn. If learning theorists are correct, children have their own ways of looking at things and those ways can be delineated in somewhat definable stages. Added to that, children change those ways of looking at the world and develop higher level thinking patterns by active interaction with their world. If this aerospace guide is to improve a child's way of thinking about things, it is important to know something about the normal course of intellectual development. With an understanding of the characteristics of the intuitive stage, content was selected for the primary level that should help the child move from intuitive thought to the more logical thought that appears in the stage of concrete operations. Appreciating how a child thinks at the stage of concrete operations, material was selected for the middle grades that would strengthen children's logical operations and help them move to the onset of propositional thinking.

Included is a detailed list of developmental behaviors taken from, Change Stages 1 & 2 and Background (A Unit for Teachers) Published for the Schools Council by Macdonald Educational, London, England, 1973. It is included , not only to give teachers a better understanding of the foundation for selection of activities, concepts and skills but in the hope that teachers will be able to use the list to "spot" their own students' levels. Whether these students seem to be thinking on a higher or lower level, the list may aid the teacher in determining where these children are developmentally and more appropriate lessons in the guide can be found for them.

ON DEVELOPING AN INQUIRING MIND AND A SCIENTIFIC APPROACH TO PROBLEMS

Stage 1 - Transition from Intuition to Concrete Operations
Grades K, 1, 2

The characteristics of thought among children differ in important respects from those of children over the age of about seven years. The young child's thought has been described as "Intuitive" by Piaget; it is closely associated with physical action and is dominated by immediate observation. Generally, the young child is not able to think about or imagine the consequences of an action unless she/he has actually carried it out, nor is she/he yet likely to draw logical conclusions from his or her experiences. At this early stage the objectives are those concerned with active exploration of the immediate environment and the development of ability to discuss and communicate effectively; they relate to the kinds of activities that are appropriate to these young children, and which form an introduction to ways of exploring and ordering observations.

Attitudes, Interests and Aesthetic Awareness
1. Willingness to ask questions.
2. Willingness to handle both living and non-living material.
3. Sensitivity to the need for giving proper care to living things.
4. Enjoyment in using all the senses for exploring and discriminating.
5. Willingness to collect material for observation or investigation.

Observing, Exploring and Ordering Observations
1. Appreciation of the variety of living things and materials in the environment.
2. Awareness of changes which take place as time passes.
3. Recognition of common shapes--square, circle, triangle.
4. Recognition of regularity in patterns.
5. Ability to group things consistently according to chosen or given criteria.

Developing Basic Concepts and Logical Thinking
1. Awareness of meaning of words which describe various types of quantity.
2. Appreciation that things which are different may have common features.

Posing Questions and Devising Experiments or Investigations to Answer Them
1. Ability to find answers to simple problems by investigation.
2. Ability to make comparisons in terms of one property or variable.

Acquiring Knowledge and Learning Skills
1. Ability to discriminate between different materials.

2. Awareness of the characteristics of living things.
3. Awareness of properties which materials can have.
4. Ability to use displayed reference material for identifying living and non-living things.

Communicating

1. Ability to use new words appropriately.
2. Ability to record events in their sequences.
3. Ability to discuss and record impressions of living and non-living things in the environment.
4. Ability to use representational symbols for recording information on charts or block graphs.

Appreciating Patterns and Relationships

1. Awareness of cause-effect relationships.

Interpreting Findings Critically

1. Awareness that the apparent size, shape and relationships of things depend on the position of the observer.

Concrete Operations. Early Stages.
Grades 1, 2, 3

In this stage, children are developing the ability to manipulate things mentally. At first this ability is limited to objects and materials that can be manipulated concretely, and even then only in a restricted way. The objectives here are concerned with developing these mental operations through exploration of concrete objects and materials--that is to say, objects and materials which, as physical things, have meaning for the child. Since older children, and even adults prefer an introduction to new ideas and problems through concrete example and physical exploration, these objectives are suitable for all children, whatever their age, who are being introduced to certain science activities for the first time.

Attitudes, Interests and Aesthetic Awareness

1. Desire to find out things for oneself.
2. Willing participation in group work.
3. Willing compliance with safety regulations in handling tools and equipment.
4. Appreciation of the need to learn the meaning of new words and to use them correctly.
5. Awareness that there are various ways of testing out ideas and making observations.
6. Interest in comparing and classifying living or non-living things.
7. Enjoyment in comparing measurements with estimates.
8. Awareness that there are various ways of expressing results and observations.

9. Willingness to wait and to keep records in order to observe change in things.
10. Enjoyment in exploring the variety of living things in the environment.
11. Interest in discussing and comparing the aesthetic qualities of materials.

Observing, Exploring and Ordering Observations

1. Awareness of the structure and form of living things.
2. Awareness of change of living things and non-living materials
3. Recognition of the action of force.
4. Ability to group living and non-living things by observable attributes.
    a. ability to distinguish regularity in events and motion.

Developing Basic Concepts and Logical Thinking

1. Ability to predict the effect of certain changes through observation of similar changes.
2. Formation of the notions of the horizontal and the vertical.
3. Development of concepts of conservation of length and substance.
4. Awareness of the meaning of speed and of its relation to distance covered.

Posing Questions and Devising Experiments or Investigations to Answer Them

1. Appreciation of the need for measurement.
2. Awareness that more than one variable may be involved in a particular change.

Acquiring Knowledge and Learning Skills

1. Familiarity with sources of sound.
2. Awareness of sources of heat, light and electricity.
3. Knowledge that change can be produced in common substances.
4. Appreciation that ability to move or cause movement requires energy.
5. Knowledge of differences in properties between and within common groups of materials.
6. Appreciation of man's use of other living things and their products.
7. Awareness that man's way of life has changed through the ages.
8. Skill in manipulating tools and materials.
9. Development of techniques for handling living things correctly.
10. Ability to use books for supplementing ideas or information.

Communicating

1. Ability to tabulate information and tables.
2. Familiarity with names of living things and non-living materials.
3. Ability to record impressions by making models, painting and drawing.

Appreciating Patterns and Relationships

1. Development of a concept of environment.
2. Formation of a broad idea of variation in living things.
3. Awareness of seasonal changes in living things.
4. Awareness of differences in physical conditions between different parts of the Earth.

Interpreting Findings Critically

1. Appreciation that properties of materials influence their use.

Stage 2 - Concrete Operations. Later Stage.
Grades 3, 4, 5

In this stage, a continuation of what Piaget calls the stage of concrete operations, the mental manipulations become more varied and powerful. The developing ability to handle variables--for example, in dealing with multiple classification--means that problems can be solved in more ordered and quantitative ways than was previously possible. The objectives begin to be more specific to the exploration of the scientific aspects of the environment rather than to general experience, as previously. These objectives are developments of those of Stage 1 and depend on them for a foundation. They are those thought of as being appropriate for all children who have progressed from Stage 1 and not merely for nine-to-eleven-year-olds.

Attitudes, Interests and Aesthetic Awareness

1. Willingness to cooperate with others in science activities.
2. Willingness to observe objectively.
3. Appreciation of the reasons for safety regulations.
4. Enjoyment in examining ambiguity in the use of words.
5. Interest in choosing suitable means of expressing results and observations.
6. Willingness to assume responsibility for the proper care of living things.
7. Willingness to examine critically the results of their own and other's work.
8. Preference for putting ideas to test before accepting or rejecting them.
9. Appreciation that approximate methods of comparison may be more appropriate than careful measurement.
10. Enjoyment in developing methods for solving problems or testing ideas.
11. Appreciation of the part that aesthetic qualities of materials play in determining their use.
12. Interest in the way discoveries were made in the past.

Observing, Exploring and Ordering Observations

1. Awareness of internal structure in living and non-living things.
2. Ability to construct and use keys for identification.
3. Recognition of similar and congruent shapes.
4. Awareness of symmetry in shapes and structures.
5. Ability to classify living things and non-living materials in different ways.
6. Ability to visualize objects from different angles and the shape of cross-sections.

Developing Basic Concepts and Logical Thinking

1. Appreciation of measurement as division into regular parts and repeated comparison with a unit.
2. Appreciation that comparisons can be made indirectly by use of an intermediary.
3. Development of concepts of conservation of weight, area and volume.
4. Appreciation of weight as a downward force.
5. Understanding of the speed, time, distance relation.

Posing Questions and Devising Experiments or Investigations to Answer Them

1. Ability to frame questions likely to be answered through investigations.
2. Ability to investigate variables and to discover effective ones.
3. Appreciation of the need to control variables and use controls in investigations.
4. Ability to choose and use either arbitrary or standard units of measurement as appropriate.
5. Ability to select a suitable degree of approximation and work to it.
6. Ability to use representational models for investigating problems or relationships.

Acquiring Knowledge and Learning Skills

1. Knowledge of conditions which promote changes in living things and non-living materials.
2. Familiarity with a wide range of forces and of ways in which they can be changed.
3. Knowledge of sources and simple properties of common forms of energy.
4. Awareness of some discoveries and inventions by famous scientists.
5. Knowledge of ways to investigate and measure properties of living things and non-living materials.
6. Knowledge of the origins of common materials.
7. Awareness of changes in the design of measuring instruments and tools during man's history.
8. Skill in devising and constructing simple apparatus.
9. Ability to select relevant information from books or other reference material.

Communicating

1. Ability to use non-representational symbols in plans, charts, etc.
2. Ability to interpret observations in terms of trends and rates of change.
3. Ability to use histograms and other simple graphical forms for communicating data.
4. Ability to construct models as a means of recording observations.

Appreciating Patterns and Relationships

1. Awareness of sequences of change in natural phenomena.
2. Awareness of structure-function relationship in parts of living things.

3. Appreciation of interdependence among living things.
4. Awareness of the impact of man's activities on other living things.
5. Awareness of the changes in the physical environment brought about by man's activity.
6. Appreciation of the relationships of parts and wholes.

Interpreting Findings Critically

1. Appreciation of adaptation to environment.
2. Appreciation of how the form and structure of materials relate to their function and properties.
3. Awareness that many factors need to be considered when choosing a material for a particular use.
4. Recognition of the role of chance in making measurements and experiments.

Stage 3 - Transition to Stage of Abstract Thinking
Grades 5, 6, 7

This is the stage in which, for some children, the ability to think about abstractions is developing. When this development is complete their thought patterns are capable of dealing with the possible and hypothetical, and are not tied to the concrete and to the here and now. It may take place between eleven and thirteen for some able children, for some children it may happen later, and for others it may never occur. The objectives of this state are ones which involve development of ability to use hypothetical reasoning and to separate and combine variables in a systematic way. They are appropriate to those who have achieved most of the Stage 2 objectives and who now show signs of ability to manipulate, mentally, ideas and propositions.

Attitudes, Interest and Aesthetic Awareness

1. Acceptance of responsibility for their own and other's safety in experiments.
2. Preference for using words correctly.
3. Commitment to the idea of physical cause and effect.
4. Recognition of the need to standardize measurements.
5. Willingness to examine evidence critically.
6. Willingness to consider beforehand the usefulness of the results from a possible experiment.
7. Preference for choosing the most appropriate means of expressing results or observations.
8. Recognition of the need to acquire new skills.
9. Willingness to consider the role of science in everyday life.
10. Appreciation of the main principles in the care of living things.
11. Willingness to extend methods used in science activities to other fields of experience.

Observing, Exploring and Ordering Observations

1. Appreciation that classification criteria are arbitrary.

2. Ability to distinguish observations which are relevant to the solution of a problem from those which are not.
3. Ability to estimate the order of magnitude of physical quantities.

Developing Basic Concepts and Logical Thinking

1. Familiarity with relationships involving velocity, distance, time acceleration.
2. Ability to separate, exclude or combine variables in approaching problems.
3. Ability to formulate hypotheses not dependent upon direct observation.
4. Ability to extend reasoning beyond the actual to the possible.
5. Ability to distinguish a logically sound proof from others less sound.

Posing Questions and Devising Experiments or Investigations to Answer Them

1. Attempting to identify the essential steps in approaching a problem scientifically.
2. Ability to design experiments with effective controls for testing hypotheses.
3. Ability to visualize a hypothetical situation as a useful simplification of actual observations.
4. Ability to construct scale models for investigation and to appreciate implications of changing the scale.

Acquiring Knowledge and Learning Skills

1. Knowledge that chemical changes result from interaction.
2. Knowledge that energy can be stored and converted in various ways.
3. Awareness of the universal nature of gravity.
4. Knowledge of main constituents and variations in the composition of soil and of the earth.
5. Knowledge that properties of matter can be explained by reference to its particular nature.
6. Knowledge of certain properties of heat, light, sound, electrical, mechanical and chemical energy.
7. Knowledge of a wide range of living organisms.
8. Development of the concept of an internal environment.
9. Knowledge of the nature and variations in basic life processes.
10. Appreciation of levels of organization in living things.
11. Appreciation of the significance of the work and ideas of some famous scientists.
12. Ability to apply relevant knowledge without help of contextual cues.
13. Ability to use scientific equipment and instruments for extending the range of human senses.

Communicating

1. Ability to select the graphical form most appropriate to the information being recorded.
2. Ability to use three-dimensional models or graphs for recording results.
3. Ability to deduce information from graphs: gradient, area, intercept.
4. Ability to use analogies to explain scientific ideas and theories.

Appreciating Patterns and Relationships

1. Recognition that the ratio of volume to surface area is significant.
2. Appreciation of the scale of the universe.
3. Understanding of the nature and significance of changes in living and non-living things.
4. Recognition that energy has many forms and is conserved when it is changed from one form to another.
5. Recognition of man's impact on living thing--conservation, change, control.
6. Appreciation of the social implications of man's changing use of materials, historical and contemporary.
7. Appreciation of the social implications of research in science.
8. Appreciation of the role of science in the changing pattern of provision for human needs.

Interpreting Findings Critically

1. Ability to draw from observations, conclusions that are unbiased by preconception.
2. Willingness to accept factual evidence despite perceptual contradictions.
3. Awareness that the degree of accuracy of measurements has to be taken into account when results are interpreted.
4. Awareness that unstated assumptions can affect conclusions drawn from argument or experimental results.
5. Appreciation of the need to integrate findings into a simplifying generalization.
6. Willingness to check that conclusions are consistent with further evidence.

These Stages chosen here conform to modern ideas about children's learning. They conveniently describe for us the mental development of children between the ages of five and thirteen years, but it must be remembered that ALTHOUGH CHILDREN GO THROUGH THESE STAGES IN THE SAME ORDER THEY DO NOT GO THROUGH THEM AT THE SAME RATES.

SOME: children achieve the later Stages at an early age.

SOME: linger in the early Stages for quite a time

SOME: never have the mental ability to develop to the later Stages.

ALL: appear to be ragged in their movement from one Stage to another.

These Stages, then, are not tied to chronological age, so in any one group of children there will be, almost certainly, some children at differing Stages of mental development.

TEACHING STRATEGIES

As was mentioned in "Helping Children Learn," learning theorists generally agree that children need active interaction with their real world--they need "stuff" to work with in order to relate new concepts to their own lives. We know, however, that it is not enough for them to have objects to work with nor is it enough that they do activities. What students also need is interaction with a teacher who can help them take the time to think about what they have done, to help them examine the process they went through, to evaluate that process with them, and to have fun with them while they do those things.

The way a teacher interacts with children during and following a lesson will make a difference in not only cognitive learning but in the child's attitude toward the process of knowing. The spirit with which a teacher approaches these aerospace activities is as important, then, as are the activities themselves.

Included in the following is a description of the three types of lessons you will find in this guide and an outline of teacher verbal skills that will help to make the lessons even more meaningful and useful for the children.

Teaching Style

Though there are many ways to present a lesson, most of the lessons in this Guide will be presented in one of the following three teaching styles:[2]

EXPOSITORY

Definition: This model involves the presentation by the teacher of the facts, concepts, generalizations, theories, skills, etc., which students are expected to learn. In general, it involves the teacher as an intermediary between scholars or the field of science such as a biologist who generates conclusions in some form. This model is quite often justified as being most efficient in the teaching/learning time.

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[2] Adapted from...Joyce,B., & Weil, M. Models of teaching (2nd ed.). Englewood Cliffs, N.J.: Prentice Hall, 1980.

Purposes: To achieve content goals, to develop specific science related skills (metric system, use of equipment, graphing and other data collection skills, etc.) to gain knowledge of facts and explain phenomena.

Features: High teacher talk, large group instruction, little student interaction, frequent displays and exhibits or demonstrations.

Teaching Skills: Instructional procedures are characterized by such things as lecturing, recitation, use of audio-visual materials, student reading of textural materials and teacher demonstrations.

GUIDED DISCOVERY

Definition: This approach involves channeling student's activities so that they proceed through some or all the inquiry elements relating to a problem which a scientist has already completed. The basic idea is to lead students through inquiry, enabling students to generate independently, conclusions, concepts, generalizations, etc., similar to those of the scholar. In general, the intellectual problems to be inquired into and the elements of the inquiry are selected by the teacher, thus the term "guided" discovery.

Purpose: To achieve process goals, to gain working understanding (as opposed to verbal understanding) of concepts, principles and generalizations and to produce users and understandings of scientific procedures.

Features: Frequent discussion sessions, laboratory work, student to student interaction.

Teaching Skills: Instructional procedures are characterized by selection of appropriate problems, motivating students, structuring activities, building student's actions and leading large group and small group discusssions.

OPEN DISCOVERY

Definition: This model involves the teacher as a facilitator who assists, rather than directs, student inquiry into intellectual problems which, in many cases, the students themselves have selected. The problems and inquiries may or may not have been taken up previously by scholars. Thus, the approach is much more open-ended and the results less predictable than in the guided inquiry approach. The students choose their own problem, their own inquiry strategies, and rather than teach the students elements of a predetermined inquiry strategy, the teacher encourages student experimentation and recognizes possible failure in the use of particular strategies.

Purpose: To provide opportunities to identify problems and for the application of understanding concepts and problem solving skills in the investigation of those real world or contrived problems.

Features: Discussions of real world problems, individual and small group work, laboratory and out of school work.

Teaching Skills: Instructional skills are similar to those in guided inquiry. They require, however, more flexibility and responsiveness to students than any of the teaching models. A type of creative improvisation on the part of the teacher is required.

A model of the three strategies may look like the following:

	Who determines the problem to be solved?	Who determines the process to be used to solve the problem?	Who actually solves the problem?
EXPOSITORY	Teacher	Teacher	Student
GUIDED DISCOVERY	Teacher	Student	Student
OPEN DISCOVERY	Student	Student	Student

Teacher Verbal Skills in Science [3]

1. Questioning Skills

If a goal of science is to further develop students' higher thought processes through discovery-inquiry techniques, the types of questions and problems students are presented with becomes a very important consideration. Recall and memory-type questions (lower-order questions) have a very definite place in all science areas but it is primarily the open-ended, divergent and probing questions (higher-order questions) which allow students the opportunity to use ideas rather than just remember them.

Higher-order questions are questions which require students to evaluate, infer, hypothesize, compare, apply a concept or principle, solve a problem, perceive cause and effect, project themselves into historical situations, and draw up new ideas.

Some Guide Lines for Effective Questioning:

A. Try to use more open-ended, divergent questions in contrast to convergent closed questions.

1.	What did you observe?	vs	How far did your plane fly?
2.	Tell me about your kite?		What shape is your kite?
3.	What happened in your experiment?		Did you find out if you were right?
4.	What objects are in your system?		Is the rudder in your system?

B. Try not to continually establish a T-C T-C T-C question and response pattern. It turns into an interrogation session not a discussion. The teacher is always forced to ask another question and the burden of thinking is on the teacher. Little child-child interaction will result. Questions which can be answered by a "yes" or "no" are directive and tend to limit possibilities for the children to express other ideas.

T - What color is your balloon?
C - Yellow
T - Is it hard?
C - No
T - Is it soft?
C - Yes
T - How does it feel?
C - Soft

It would have been better to say something like, "Tell me something about your balloon."

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[3] Staley, F. A comparison study of the effects of pre-service teachers presenting one or two micro-teaching lessons to different sized groups of peers on selected teaching behaviors and attitudes in an elementary science methods course (Doctoral dissertation, Arizona State University, 1971). Dissertation Abstracts International, 1972, 2301-A. 43-7.

C. If you want to know something specific ask for an answer directly. Don't fish around and establish the mind-reading game. If you ask an open-ended question, accept the divergent responses you will get. Don't search for your preconceived answer.

T - What did you observe about the airport?
C - It has lots of planes.
T - Yes
C - Some are big and some are little
T - I see.
C - They make noise
T - Fine.
C - They have wings.
T - How many wings?
C - Two.
T - Hmm.
C - They have wheels.
T - How many?
C - Two, too.
T - Anything else?
C - They have propellers.
T - I'm glad someone mentioned propellers. How many propellers are there?
C - 3.
T - Really?
C - 4
C - 2
T - What do you think?
C - I wasn't looking at the propellers!

D. Be careful not to use too many fill-in-the-blank type questions. It promotes guessing for the right answer.

T - This part of the rocket is big and ______________________.

Avoid making statements and putting them in the form of a question.

T - The balloons are all the same color, aren't they?

2. Response (to pupil comment or answer) Skills

A. Teachers need to develop a repertoire of responses to the comments and responses children make. Initially children need a great deal of praise and encouragement. No one response should be used for every occasion. As the teacher and children continue to work with the materials, the teacher should try to make more neutral or fewer responses to the children's comments in order to promote more interaction between the children.

Examples of responses:

I see.
That's an interesting idea.
Thank you.
O.K.
Repeat answer.
Alright.
What evidence do you have that...
Fine.
Can you show us?
Silence
Do you agree with Jon's idea?
How could we find out?
That's a possibility.
I don't agree.

B. Any distinct pattern you may establish may be expected by a child and any deviation from that pattern may be misunderstood as a negative response.

T - Tell me about this object? (rocket)

C - It's round.
T - Good.
C - It's tall
T - Good
C - It's got two engines on it.
T - Good.
C - It's shiny.
T - It's shiny.
C - Well, not exactly shiny.

C. Be aware of the positive-negative type response you can make.

C - It will fly.
T - Yes, but....

D. Be aware of responses made by children that may be a clue to the teacher that she has been giving too many or too much reinforcement or positive approval.

Child answers questions in question form. Ex.: C - It is going to crash?

Child looks at teacher for approving eye. (The teacher should try to focus her attention on the object itself, instead of the face of the child.)

3. Wait Skills

A. Wait time after a teacher question--

If students are being required to think more because of the use of higher order questions, the period of time that a teacher should wait for students to construct a response to a question should increase.
If, for example, more than one pattern can be imposed on a heap of objects (like buttons) the student requires more time to process alternatives and decide which orderings are meaningful for him or her at that point in time.

Ask a question and follow it by silence. How long can you wait before you find it uncomfortable for you? Practice that skill.

Many children have learned to out-wait the teacher because sometimes teachers answer their own questions and do all the thinking for the children.

T - What shape is your object?
C - No response
T - It's kind of like a bird, isn't it?
C - Yes.

B. Wait time before a teacher response--

Research shows that teachers tend to wait less than a second after a question is asked by them or a response is given to their question before the teacher responds again. The period of time a teacher waits before replying to a student response should increase in order to promote higher level thinking on the student's part. In addition, since the student may "open" with a variety of potentially acceptable responses (by virtue of the fact that there are more acceptable alternatives), the teacher needs to hear what the student really said. If the teacher shifts the grounds for discourse with his or her next response, then the student often learns to monitor the teacher rather than the system of objects. (For example: C - "It's skinnier" T - "You mean tall." The student may not have meant that at all but the child may now buy into what the teacher responded with rather than what the student actually meant.)

4. Other Verbal Skills

In general you should hear yourself asking these types of questions:

"How well did we do this?"

"Was our plan good? What can we do to make it better?"

"Where can we get information?"

"What is there about __________ that makes you think ________?"

"How are they alike? How are they different?"

"What is the problem?"

"What would happen if __________________?"

"Where could you find __________________?"

"How could you make a __________________?"

"Do you think we can demonstrate _________________?"

If your children are using higher order thinking skills, you should hear these kinds of questions from them:

"If that's true, why _________________?"

"I understand that but, why __________________?"

"How could that happen?"

"Where did you find that information?"

"How do you know that's true?"

"Can we try that again?"

36

"OVER THE RAINBOW"

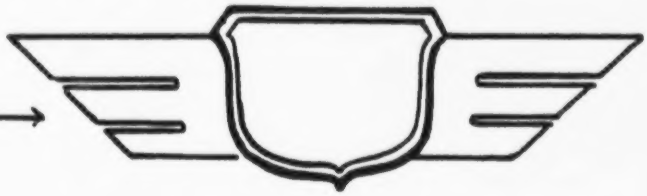
> "AT THE BEGINNING IS CURIOSITY, AND WITH CURIOSITY THE DELIGHT IN MASTERY - THE JOY OF FIGURING IT OUT THAT IS THE BIRTHRIGHT OF EVERY CHILD."
>
> HORACE FREELAND JUDSON
> SEARCH FOR SOLUTIONS

1. WHAT FLIES?
2. ROCKET SHAPES
3. WHAT'S UP?
4. ORDERING ROCKETS
5. CHARTING THE WEATHER
6. ROCKET RULER

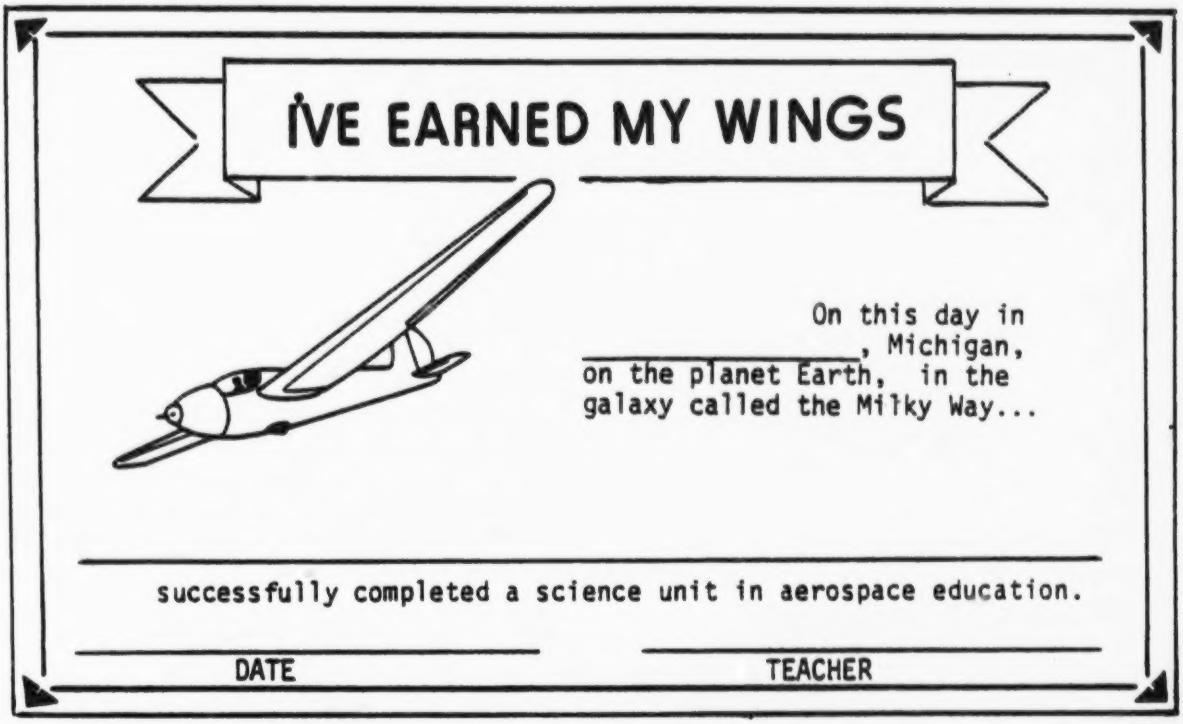
A SPECIAL SOMETHING TO DO....

To the Teacher:

After your students have completed an aviation and aerospace unit (either a grade level set of activities or specific activities of your choice), you might like to give them their "wings." Reproduce the wings and certificate below. Attach the wings to light cardboard for stability. Bestow both to your students with dignity, honor and celebration.



Print student's name in center of "Wings."



I'VE EARNED MY WINGS

On this day in
_______________, Michigan,
on the planet Earth, in the
galaxy called the Milky Way...

____

successfully completed a science unit in aerospace education.

_______________________ DATE

_______________________ TEACHER

WHAT FLIES?

1

Objectives: To improve observation and classification skills.

Materials: Worksheet. Crayons.

Procedure: Duplicate and distribute worksheets (following next page) and ask if students have seen any of the items. As they say, "Yes," to some, ask what they have noticed about it when they saw it. Ask what they notice now in the picture of it. Ask whether some of the items are similar and, if so, how they are alike. What do you notice that shows alikeness? Ask how they are ALL alike? Ask if some are different from others and ask in what ways they are different.

After similarities and differences have been talked about, discuss classifying the items into living and non-living groups. Have children circle living things in one color and non-living things in another color. Ask questions like: Which of these is a living thing? Which is not a living thing? What is it about the item that made you decide it is (or is not) living? After they have finished, they can color the items as they choose.

Extensions: Do other classifications like SOUND (Noisy and Quiet) or SIZE (big and little). Make your own worksheet using items like the rocket, airplane and helicopter for noisy and the balloon, snowflake and seed for quiet, for example. Or, you can use the same items for big and little but make sure you draw the items appropriately larger and smaller. As much as you can, let these activities involve active interaction with the item itself. Listen to a helium balloon rising or to a floating snowflake or take the time to listen when a plane flies over.

For TEXTURE, you might have children use cotton balls to make clouds and then draw a picture using the clouds in the sky. Or attach cotton ball clouds to colored pipe cleaners that have been formed to make an arc for a nifty clouds and rainbow that can be hung. Or, have children touch a balloon filled full with air and one not so full and discuss what they notice. They can touch green leaves and leaves that have turned brittle and yellow and talk about the changes. Ask what specific differences they notice between the two.

SUBJECT:

Science

GRADE:

Kindergarten

GROUP SIZE:

Large or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Discussion

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

What Flies?

SKILLS:

Observing
Recall
Classifying

RESOURCES:

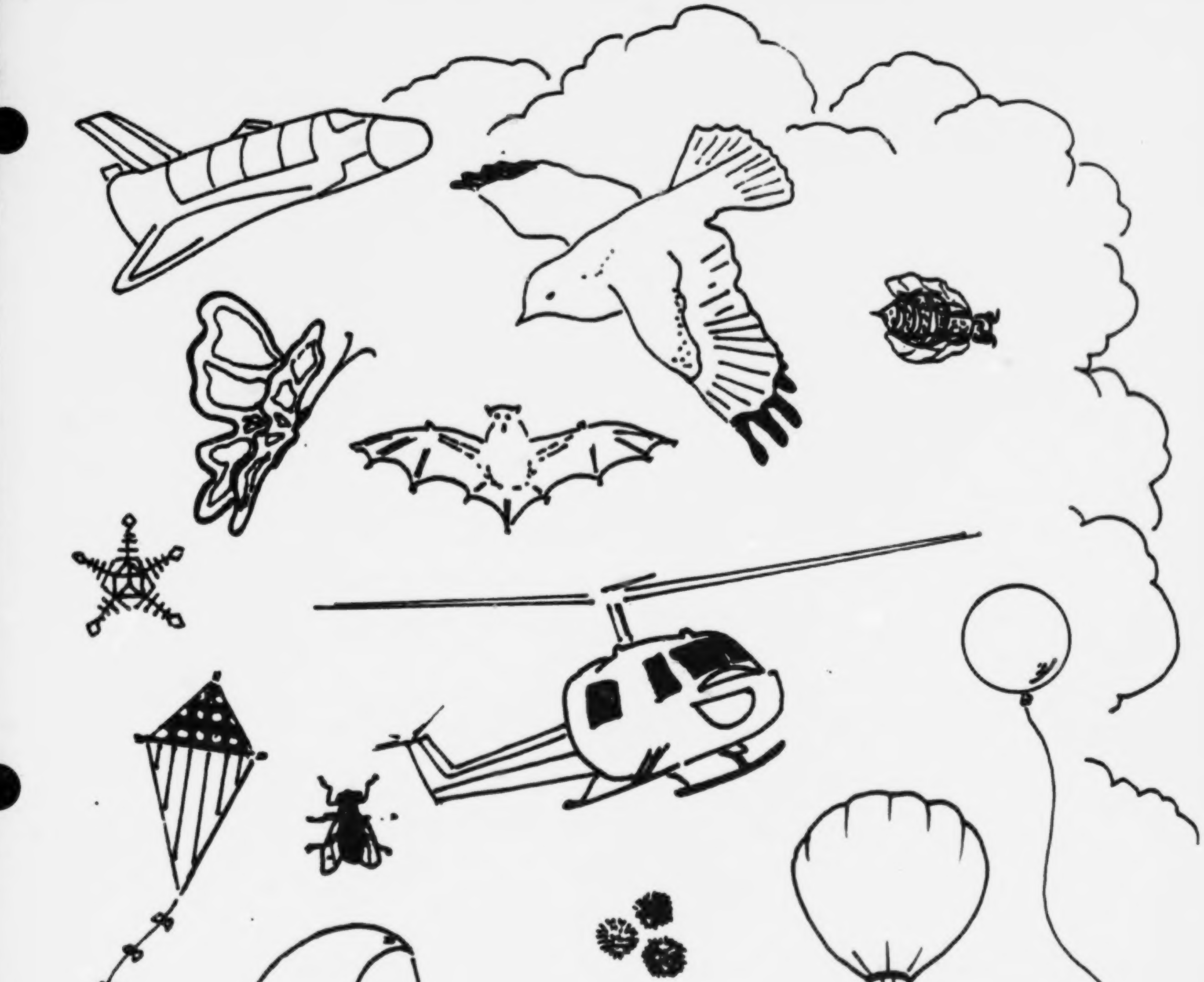
65, 70, 72,
83, 86, 89

WHAT FLIES (con't)

Use the worksheet as an Inventory List. Have students look for items for real, or in magazines or on TV and have them cross the item off as they see it. Ask them about what they noticed when they saw it and, when they've found pictures or the actual item, have them bring it in for a flying bulletin board. Let them tell you and other children what they noticed about the item.

Discuss which items students can fly now and the ones which they can fly when they are older. Take a minute to talk about what it might be like to be a pilot or a hot-air balloonist and how they might get to be one. Ask if they know any pilots or balloonists. If they have flown, ask them describe it. What did they notice? How did they feel?

For 1st grade, ask students to use the worksheet to find different classifications themselves. Ask questions like, "Which of these do you think belong together?" "What did you notice that made you think so?" "What other things do you see in some of these items that could make another kind of group?"



2

ROCKET SHAPES

SUBJECT:
Science

GRADE:
Kindergarten

GROUP SIZE:
Individual

TIME:
20 minutes

TYPE OF ACTIVITY:
Puzzle
Student Investigation.

TEACHING STYLE:
Guided Discovery

CONCEPTS:
Shape
Size

SKILLS:
Observing
Motor Coordination

RESOURCES:
181, 184, 193

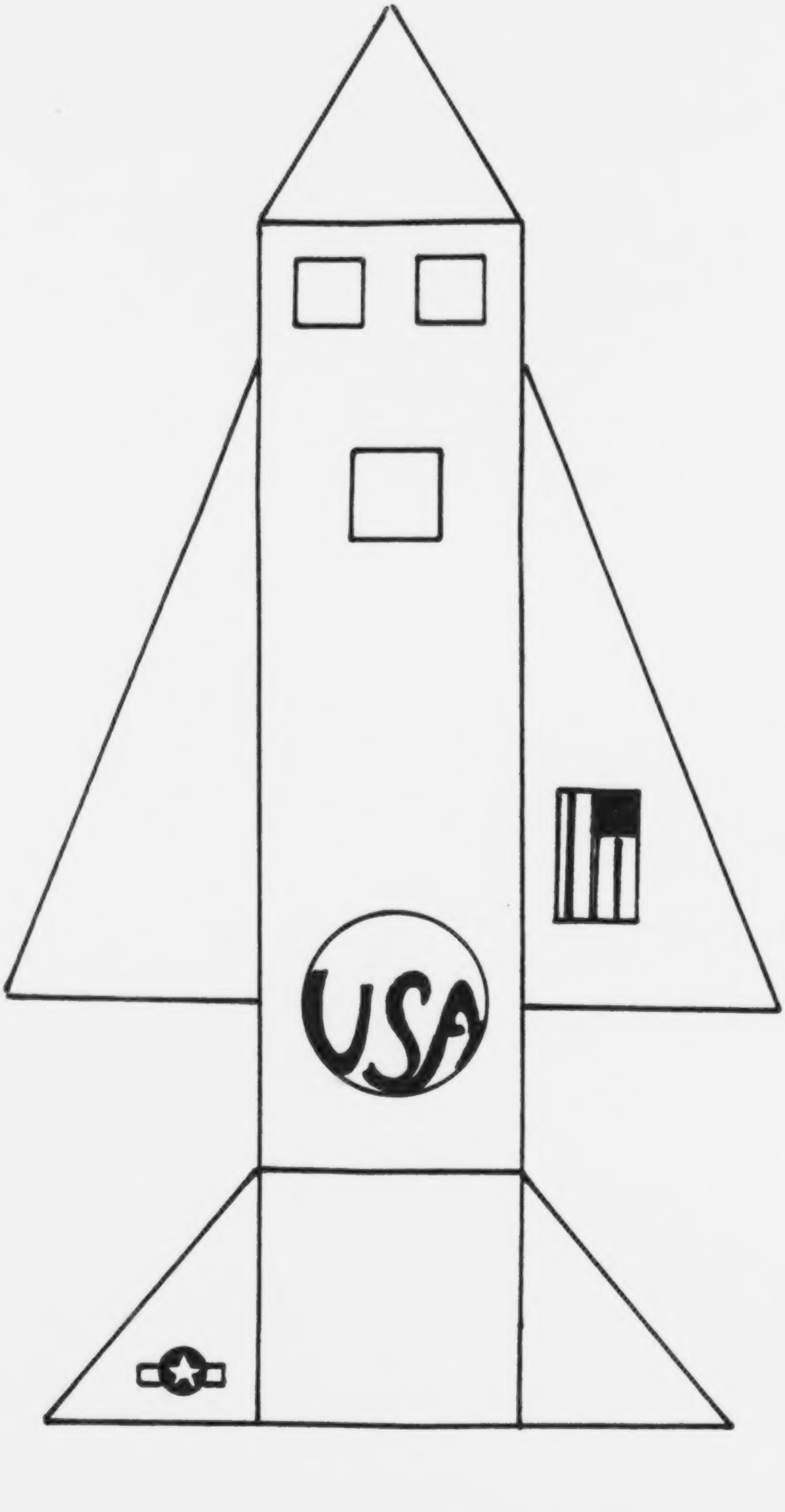
Objectives: To reinforce student's concept of triangle, circle, and rectangle (square); to have student apply concept of size.

Materials: Picture of completed rocket and rocket separated into eight basic pieces (5 triangles, 1 square, 1 rectangle, 1 circle insert) (See worksheet)

Teacher Background Information: Make the pieces by gluing to cardboard and cutting out the larger (including the USA circle) basic shapes. Protect with clear contact paper.

Procedures: Give student the "puzzle" pieces to play with and arrange in whatever fashion he or she wishes. Talk with student about the shapes, asking which are circles, squares, rectangles and triangles. Have student trace around some of the pieces to get a feeling of the shape. Give the student the worksheet showing a possible arrangement and ask him or her to make the pieces look like the picture. Ask if the student can find more of the shapes on the drawing that weren't cut out. Ask student if he/she can find a small circle and a big one; a small square and a bigger one; a big triangle and a smaller one; and the large rectangle and the small one hidden as the flag. Afterward, have student color the worksheet as he or she wants.

Extension: Have student count the number of circles, triangles, squares and rectangles. Have student make a graph of the numbers of each shape.


USA

3

WHAT'S UP?

SUBJECT:
Science

GRADE:
Kindergarten

GROUP SIZE:
Large or Small

TIME:
30 minutes

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Position
Color

SKILLS:
Observation

RESOURCES:
298

Objectives: to introduce the concept of up and down; to enhance group discussion skills.

Materials: Copies of worksheet, crayons.

Procedures: Distribute copies of the worksheet. Talk with the students about the boy's and girl's position to the balloon and the kite as it relates to up and down. Ask questions like, "What do you notice about where the balloon is?" "What do you notice about where the kite is?" "Are the balloon and kite in the same place?" "A different place?" "What do you notice that tells you where they are?"

Ask what other things are up (in the classroom) and what other things are down. Ask them to recall what was up and what was down when they were outside. Ask what they have to do physically to see what's up and what's down. After a short discussion, have the students look again at the pictures and read the captions to them. Talk about the two colors and point out the color words in the caption. Ask them to find the two colors in the room and then find the two crayons and color the balloon red and the kite blue. Then finish the pictures as they wish.

Extensions: You can get into other positions like "near and far" with questions like, "Have you ever had a helium-filled balloon get loose? What happened?" Get one and go outside and let one go. Hold it near and then far and then... gone. Or use the kite picture for behind or in front. Again, hold a kite or something else in front and behind and then let them experience in front or behind them by placing things themselves.

For older levels, you can change the caption to read "How come my balloon flew up?" or "Why did my kite come down?" and get into wind and gravity and the variables that affect those things.

MY RED BALLOON FLEW UP.

MY BLUE KITE CAME DOWN.

4

ORDERING ROCKETS

SUBJECT:
Science

GRADE:
Kindergarten

GROUP SIZE:
Small

TIME:
30 minutes

TYPE OF ACTIVITY:
Student Investigation.

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Size-Height

SKILLS:
Observing
Ordering by height

RESOURCES:
181, 190, 298

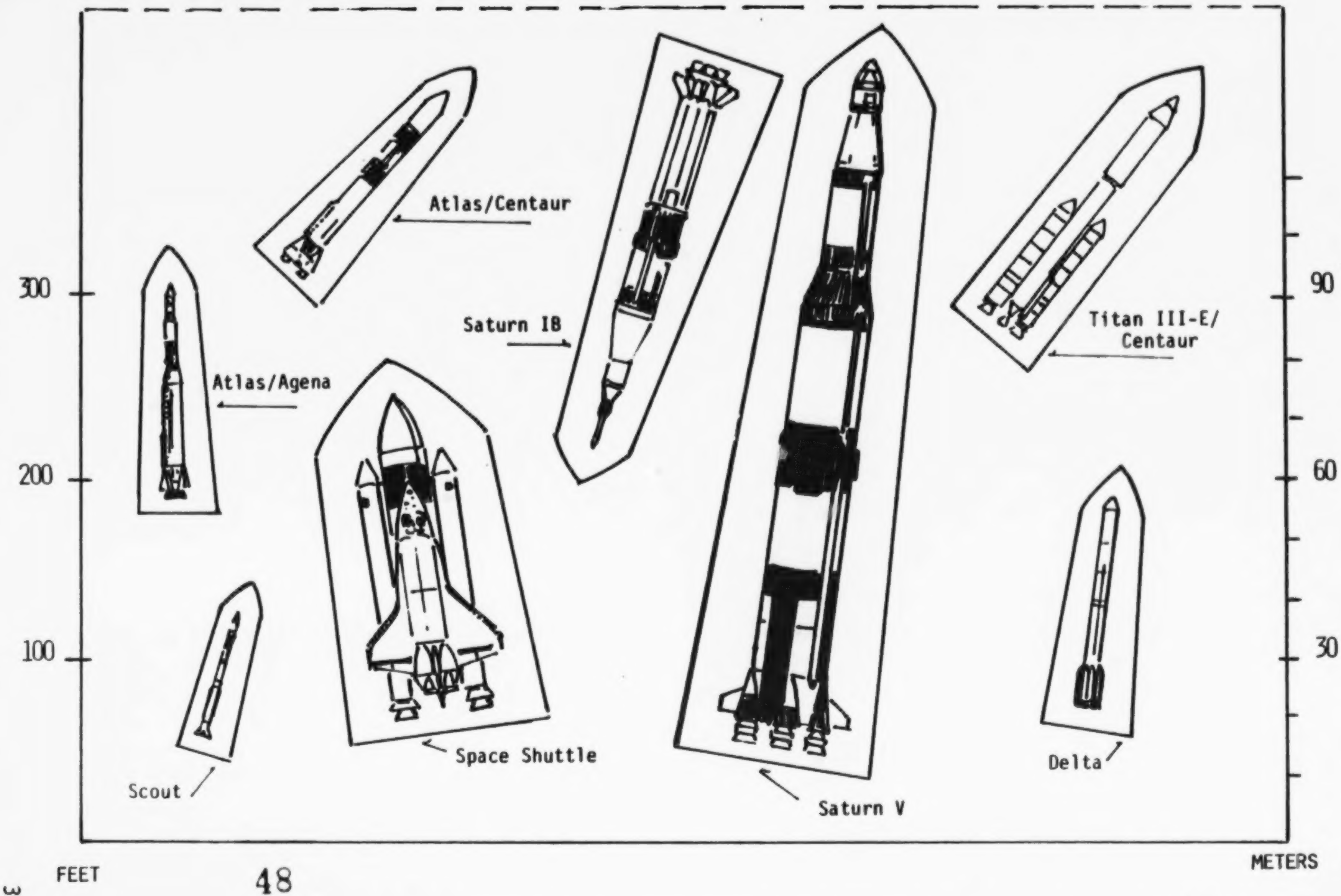
Objectives: to develop student's ability to order objects by height; to show students a sample of the variety of launch vehicles used.

Materials: 6 sets, Launch vehicle shapes (cut out, glued to cardboard and protected with clear contact paper made by teacher). 6 sheets of paper with base line drawn, crayons and a sheet of drawing paper for each child.

Procedures: Distribute sets of shapes of rockets. Talk with students about rockets and what they do. Ask where they've seen rockets and what they noticed about them. Ask about the differences in sizes of the rockets that make up the set you've given them. Ask how they might arrange the rockets from longest to shortest. Ask how they decided to place the rockets where they did. If a child has trouble, suggest he/she find the shortest and the tallest and put them on the base line at opposite ends. Help order the rest in between. (Note: The Delta and the Atlas/Agena are the same height. You may want to remove one of them if it's confusing or ask student to find the two that are the same and put them side by side on the baseline.) When they have the rockets ordered, discuss other differences in the rockets. Discuss the similarities and then ask the children to draw and color their own special variety of rocket.

Extension: Color the background portion of the rocket sets so you have 6 blue, 6 red, 6 yellow, etc. and use the rockets for counting or making sets as well as for working on colors.

For older level, use the feet/meter part of worksheet to show the relationship between feet and meters. The rockets are drawn to the scale on the sheet, so they can determine about how tall each is in both meters and feet.


Atlas/Centaur
Saturn IB
Titan III-E/
Centaur
Atlas/Agena
300
200
100
90
60
30
Scout
Space Shuttle
Saturn V
Delta
FEET
METERS

5

CHARTING THE WEATHER

SUBJECTS:

Science

GRADE:

Kindergarten

TIME:

30 minutes initially/5-8 minutes after for month

TYPE OF ACTIVITY:

Discussion

TEACHING STRATEGY:

Expository

CONCEPTS:

Weather's affect on flying
Symbols

SKILLS:

Collecting/recording data
Inferring
Group concensus

RESOURCES:

4, 11, 20, 30

Objectives: to apply observation and inference skills; to introduce collecting and recording data with pictograph.

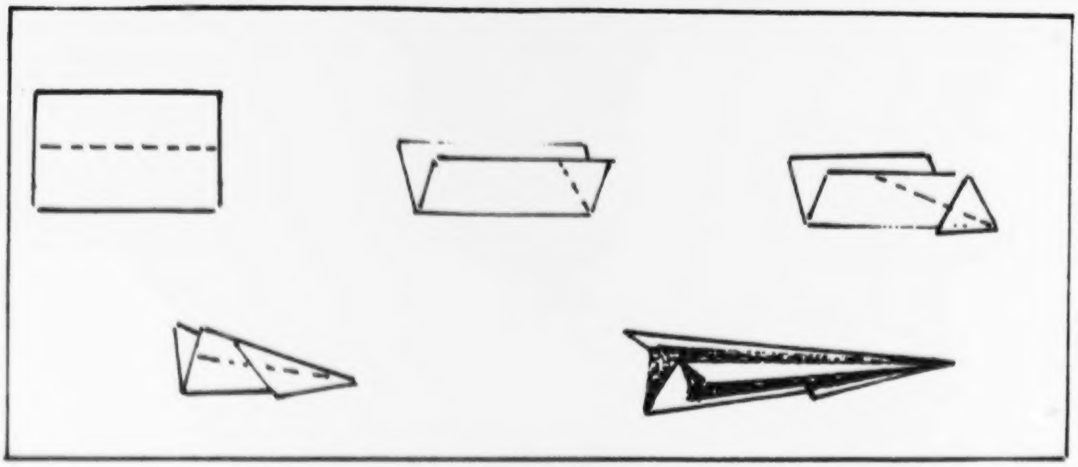
Materials: Large month-long calender. Cut outs of weather symbols (from set provided, glued to cardboard and protected with clear contact paper). Large sheets of paper for two graphs. 8 x 10 sheets of paper for each child to make paper airplane. Rubber cement.

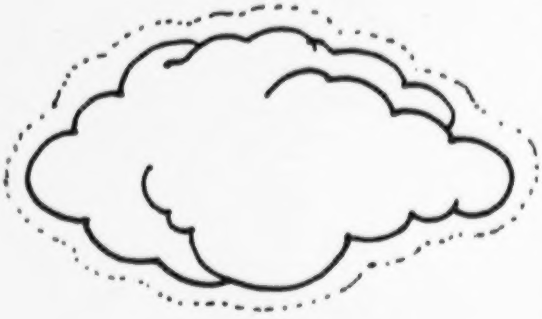
Teacher background information: Make the weather symbols and a large calendar. Make two large graphs. One should have the number of days up the left side and five columns across for Rainy, Snowy, Sunny, Cloudy and Windy. The second should have the number of days up the left side and two columns for "Flying Today" and "No Flying Today" across.

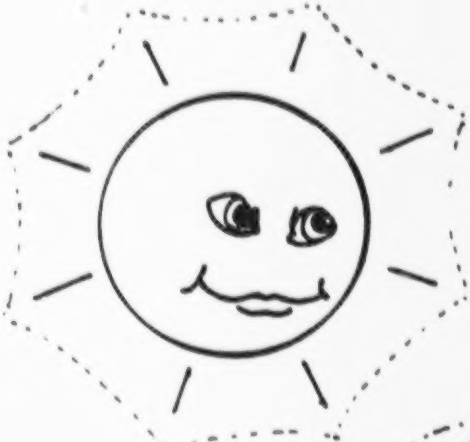
Too rainy, too windy and too snowy days are the days most small plane pilots do not fly. Your students will be basing their decisions on paper airplanes, but that's not too far different from the small plane without the fancy instrumentation of the larger ones.

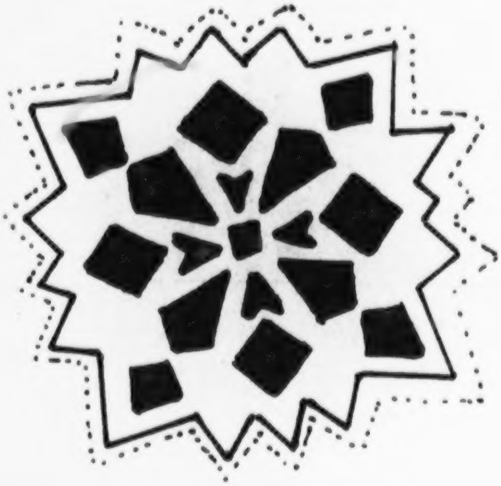
Procedure: Help the children make simple paper airplanes. Let them fly their planes inside when they are done. Put up the calendar and the graphs and explain that you will be charting the weather and deciding each day whether it's a good day to fly the paper airplanes outside. Ask questions like, "What have you noticed about the weather today?" "What did you notice yesterday?" "Similarities?" "Differences?" "What could happen outside that would make it a good day to fly?" "A bad day to fly?"

Show children symbols for the weather conditions and explain that the class will have to decide on one of them for each day. Before afternoon recess, have students first make the decision about the kind of weather. Put the symbol on the calendar with rubber cement (on one side only, so you can pull it off easily.) Have a student color the appropriate square on the first graph. Decide, given the weather conditions, if it would be a good day to fly their planes. Talk about WHY they think so. Color appropriate square on second chart. Encourage students to fly their planes on good days. At end of month, tally the different weather days and the flying and no flying days and discuss the overall conditions for the month.









6

ROCKET RULER

SUBJECT:
Science

GRADE:
Kindergarten

GROUP SIZE:
Small

TIME:
45 minutes

TYPE OF ACTIVITY:
Discussion
Student Investigation.

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Size-length/height

SKILLS:
Measuring with non-standard units
Group participation.

RESOURCES:
298

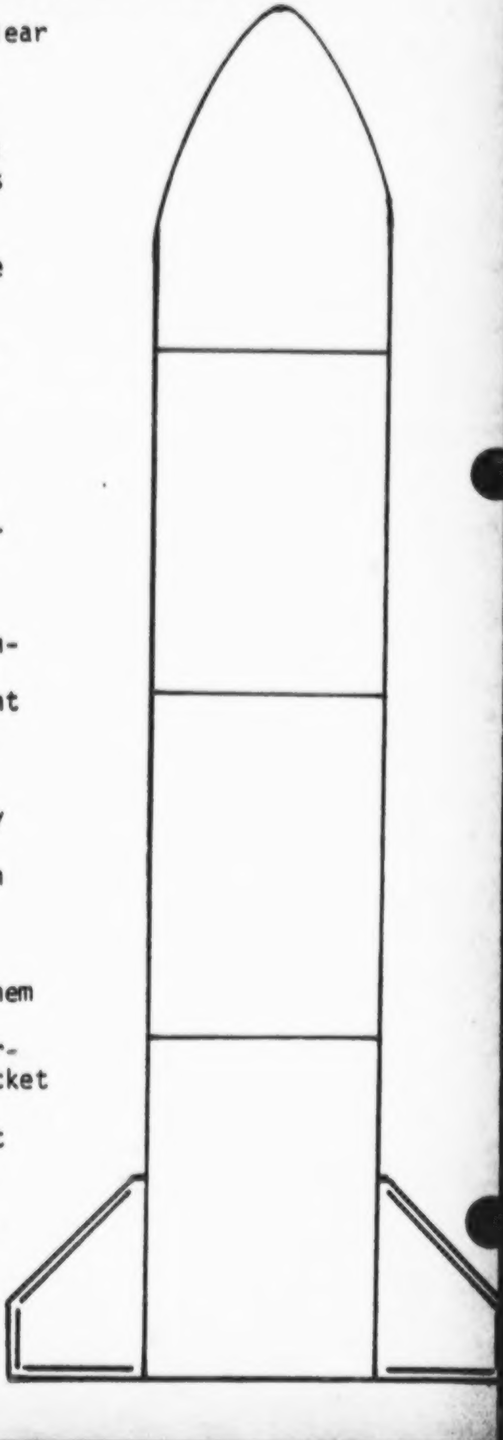
Objectives: to develop estimating and measuring skills; to promote group participation skills.

Materials: Cardboard, glue, clear contact paper and rocket ruler outline.

Teacher Background Information: Make at least six rocket rulers using outline here. Cut out shapes and glue to cardboard. Cover with contact paper. Make several extra copies of the rocket outline so that each child will have enough to tape together to make his or her height. The outline is 20 cm high.

Procedures: Show students the rocket rulers and let them handle them. Ask questions like, "How can we find out how long the desk is?" Measure it in various ways--with hands or pencils, etc. Then, estimate how many rockets long the desk might be. Measure it. Do the same with other things in the room asking the students what they would like to measure. If they don't suggest themselves, you do so and let them measure each other while you record the measurements for each.

When they finish, have them cut out the number of rockets and fraction of rocket that corresponds to their height. (Rocket is divided in quarters.) Have them color the rocket and print their name on them, tape together and hang or put on large paper in a pictograph arrangement from tallest to shortest.



"WAY UP HIGH"

"THE CONTEMPLATION OF THIS WORLD BECKONED LIKE A LIBERATION."

ALBERT EINSTEIN, 1949

"LOOK, I'M TESTING EVERYTHING!"

LAURA, AGE 8
SEED TIME: A CELEBRATION OF CHILDHOOD

7. COME DOWN TO EARTH
8. THINGS THAT FLY (AIRCRAFT AND SPACECRAFT)
9. IT'S A BIRD ... IT'S A PLANE!
10. FOOLIN' AROUND WITH AIR: FIVE ACTIVITIES
11. AIR MOVES
12. AIR PRESSURE 1 AND 2
13. IT'S A HOLD UP!!
14. DOES SHAPE MATTER?
15. LIFT OFF
16. SAFE LANDING

SPECIAL COLORING PAGE

Amelia Earhart AVIATOR

7

COME DOWN TO EARTH

Objectives: to introduce the concept of gravity; to provide students the opportunity to observe the effects of gravity.

Materials: Coloring worksheet (next page). Crayons. Balls (different sizes). Glass and liquid.

Procedure: Distribute the worksheet. Ask the students to describe the activities in the picture. Ask them to notice what objects are falling. What is being held to the earth? (The apple, leaves, ball and water are all falling; the children, dog and liquid in the glass are being held by gravity to the earth.) Talk about the pull of gravity toward the earth. Discuss why gravity is a good and helpful thing (milk stays in glasses and we don't float away, etc.) and how gravity is sometimes not helpful and has to be overcome (apples fall on our heads and that plane had to work like the dickens to get free of the earth, etc.). Discuss how we know gravity exists even though we can't see gravity itself. (We can see what it does.) Explain that other planets have different amounts of pull and ask if students have ever seen pictures on TV of astronauts free (partially) of gravity in their capsules in space or on the moon. Explain the moon is smaller than the earth and does not have as much pull. Ask what that might mean for someone on the moon. (They would weigh less and they could jump higher, for example.)

Take 2 balls of different sizes, one large and one small. Give balls to two students and have one of them stand on a chair and the other sit on the floor to observe when the balls hit the floor. Have the first student drop balls at the same time. Do the balls land at the same time? Have students try to explain why.

Have students color the picture and title it.

SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Small or Large

TIME:

45 minutes

TYPE OF ACTIVITY:

Teacher/Student Discussion

TEACHING STRATEGY:

Expository

CONCEPTS:

Gravity
Evidence

SKILLS:

Observation
Experimenting
Inference

RESOURCES:

153, 298

"Gravity Drag" - NASA Film

8

THINGS THAT FLY
(Aircraft and Spacecraft)

Objective: to learn the names and characteristics of different aircraft and spacecraft; to introduce the idea of systems.

Materials: Worksheets. Pencils. Crayons.

Procedure: Distribute the worksheets to the students. Ask them to describe the characteristics of each of the crafts. Ask what they notice about the items that is the same or similar and what is different about some of the crafts. Ask them to note that each object is made up of different parts (the monoplane has 1 set of wings, body, wheels, propellor, etc.) and these basic parts put together make a system called a monoplane.

Ask the students if they have actually seen any of the crafts and to describe the experience. Ask if they have ever flown in any of the crafts and, if so, to describe what it was like and what they noticed during the experience.

Have the students complete the first worksheet by printing the rest of the letters for the word that matches the picture. Assist to the degree that the student needs help and wants your guidance.

After the names are printed and talked about, have the students color the pictures. Then have them cut out the drawings and match them with the descriptions on the next page of the worksheets. Depending on the language ability of your students, you may include or exclude the names of the craft with their description.

SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Small or Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Discussion

TEACHING STRATEGY:

Expository
Discussion

CONCEPTS:

Diversity
Aircraft
Spacecraft
System

SKILLS:

Describing
Comparison
Matching

RESOURCES:

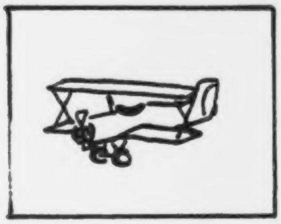
64, 68, 79,
80, 191, 193

AIRCRAFT AND SPACECRAFT

Copy the word from the list that matches the drawing. Cut out drawing and match them with the description on the next page. Color the drawings and paste in place.

helicopter monoplane shuttle

biplane rocket balloon



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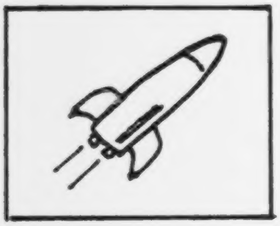

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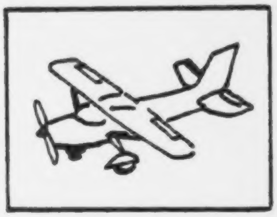

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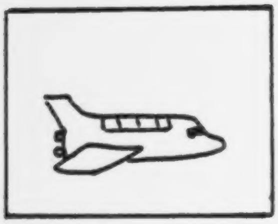

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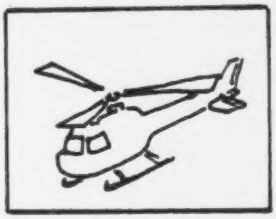

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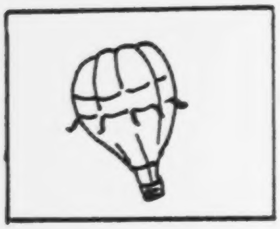

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AIRCRAFT AND SPACECRAFT

A Monoplane is a plane with one wing.

Some balloons are filled with hot air.

A helicopter has a wing that turns.

A biplane is a plane with two wings.

A rocket lifts things into space.

The space shuttle carries people
into space.

9

IT'S A BIRD ... IT'S A PLANE!

SUBJECT:
Science

GRADE:
First

GROUP SIZE:
Large

TIME:
30 minutes

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Guided Discussion

CONCEPTS:
Similarities
Differences
System

SKILLS:
Comparison
Observation

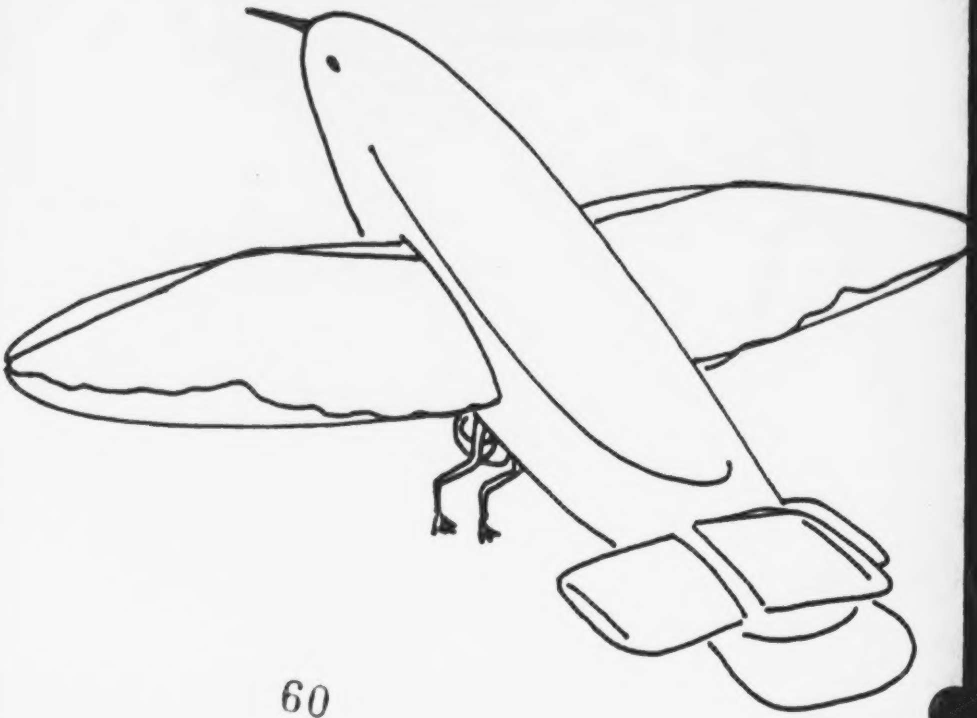
RESOURCES:
29, 42, 86

Objectives: to observe and describe similarities between birds and planes; to understand people copied birds to achieve flight.

Materials: Pictures of airplanes and birds in flight.

Procedure: Compare pictures of birds and airplanes in flight. Ask students to tell what they notice about the similarities between birds' and planes' systems. For example, they both have bodies, flat tails, wings and "feet."

After the discussion of similarities between the system called "birds" and the system called "planes," students will be able to list at least four ways that men copied the bird's system to achieve flight.



10

FOOLIN' AROUND WITH AIR

Objectives: to learn that air has a number of properties; to understand that, though air cannot be seen directly, what it does can be observed.

Materials: Plastic sandwich bags. Twisters. Garbage bags. Straws. Large Jar. Aquarium. Glass. Soda bottle. Cardboard. Perfume.

Teacher Background Information: There are several ways to let students observe that air has physical characteristics. A number of ways follow. Choose those that work for you.

Procedure: a. Ask students to catch some air in a plastic sandwich bag by holding the mouth of the bag open and swishing it through the air. Quickly close the mouth and twist it tightly to trap the air. Fasten with twister. Have the students (1) squeeze the trapped air and notice how it feels. Have them describe it. (2) Look through the sandwich bag filled with air. Can they see through it? (3) Have students smell the air in their bags by opening a bit. Let them squeeze out the air and catch other air from different places in the school or outside and ask them to describe what the air smells like.

b. Have students submerge an empty soda bottle with the top up, into an aquarium of water. Ask them to notice what happens. Have them determine whether the soda bottle was indeed "empty."

c. Have students feel the air by swinging their hands through the air. Ask them to notice the difference as they swing their hands faster and to describe what it is that they feel. Give them pieces of cardboard to swing, and ask them to notice the difference in feeling and how the cardboard pushes against something. What is that "something?" Talk about indicators of something present, even though it cannot be seen directly.

d. Have students blow up balloons. Ask them to partially fill the balloons and feel them. Hard? Soft? What's in there? Ask them to completely fill the balloon. Notice how it feels. Let the balloon open a bit and ask them to feel the air being released.

e. Have students blow up two balloons to equal weight and tie. Attach each balloon to balance scale and notice that it balances. Prick one balloon with a pin and ask the students to notice what happens as the air rushes out. Discuss weight as a property of air that indicates its existence.

SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Small or Large

TIME:

60 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Properties of air
Evidence

SKILLS:

Observation
Experimentation
Inferrence

RESOURCES:

15, 26, 32
71, 298

11

AIR MOVES

SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Experiment

TEACHING STRATEGY:

Expository

CONCEPTS:

Air moves in currents
Evidence

SKILLS:

Observation
Inference
Drawing conclusions

RESOURCES:

13, 15, 298

Objectives: to observe the flow of air in a room using indirect evidence.

Materials: Cotton balls. Strong perfume and/or other strongly scented material.

Procedure: Put scent on a piece of cotton. Ask the students to raise their hands as soon as they smell the scent. Try having a student fan a piece of paper near another scent. Does the odor travel faster through the room? Explain air currents and movement if students can not conclude that scent travels in the moving air.

Extensions: Have students observe the movement of leaves on trees, dust on the ground, or flags on poles. Ask them to notice other indicators that show when air is in motion. You might tell them that moving air is called wind. (If they have the language ability, you can go further and explain that the smell moving throughout the room is called diffusion and that currents is another name for air movement.)

You can have students brainstorm ways to make air current detectors: pinwheels, candle flames, soap bubbles in the air, circle of paper cut into spirals and hung, tissue paper hung from a stick, etc. Have them make some and use to detect the air currents in warm and cold places, high and low places, indoors and outside, in calm and windy weather, etc.

12

AIR PRESSURE 1

Objective: Students will construct a simple device which uses air pressure to move an object.

Materials: Plastic drinking straws. Plastic bags. (Sandwich size) Textbooks.

Procedure: Give each student a straw, bag and book. Ask student to invent a way to raise the book using only the materials above. Give the students ample time to explore ways of moving the book - 15 to 20 minutes.

Note: The book can be raised by placing the plastic bag under the book and blowing air into the bag with the straw.

More: Find evidence of air pressure being used to lift objects.

Extension: By using large garbage size bags, a student sitting on a flat table or board on the floor with bags under it, can be raised if several students all blow into their bags at the same time. See Activity # 15 .

AIR PRESSURE 2

Objective: To observe and conclude that air can exert pushing force.

Materials: Water glass. Water. A square piece of thin, flat cardboard or tag board about 6" square. Plastic dish pan.

Procedure: Completely fill a glass with water. Place cardboard over the glass. Carefully turn the glass upside down over the dishpan, holding the cardboard tightly against the glass.

Take your hand away from the cardboard. (The cardboard should stay in place.) Discuss the concept that the push of air against the cardboard is greater than the push of the water.

SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Student Activity

TEACHING STRATEGY:

Expository and
Guided Discussion

CONCEPTS:

Air can do work
Pressure
Evidence

SKILLS:

Observation
Drawing conclusions
Experimenting

RESOURCES:

42, 44, 298

13

IT'S A HOLD UP!!

SUBJECT:
Science

GRADE:
First

GROUP SIZE:
Large or Small

TIME:
45 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository

CONCEPTS:
Air resistance

SKILLS:
Observation
Inference

RESOURCES:
33, 35, 298

Objective: to demonstrate that objects fly only when the force of air upward (resistance) is greater than the force of gravity downward.

Materials: Balloon. Kite materials (2 sticks, paper, glue, long strip of cloth, string).

Procedure: Discuss with the students the idea that gravity is always working to keep things on the earth and that objects can fly only when the force of the air upward is greater than the force of gravity. Ask them to recall what they have seen flying or floating in the air. Leaves. Seeds. Balloons.

Fill a balloon with air. Ask if the balloon will rise. Let the balloon go and ask the students to note what happens. Try to keep the balloon up by blowing on the bottom of it with a fan or a vacuum hose hooked up to blow air out. What happens?

Make a kite (or purchase one) and take the students outside to fly it. Explain that wind pressure beneath the kite tends to hold it up but gravity tends to pull it down and that the person flying it has to hold the kite at an angle to the wind so that the air strikes against the under surface of the kite. Explain that the tail keeps the kite upright and the flyer uses the string to keep the kite headed into the wind. If there is less wind than optimum, the flyer can pull the kite to make wind pressure greater. Explain that if the string is released, the kite will fall because of gravity. It falls because the angle at which the surface of the kite has been held toward the wind has been changed. The lift upward caused by the angle at which the kite attacked the air is now less than the pull of gravity downward.

Ask them if they'd like to make and fly their own kites. Do it.

Extension: Do the parachute activity, "Safe Landing." Extend that by using different objects - a feather, a piece of paper, a pencil, etc. - and do the experiment both indoors and outside, in relatively calm and in windy weather. Compare how objects fall with and without a parachute. Explain that the parachute slows down objects by "capturing" air but not enough pressure is created to keep the object up.

14

DOES SHAPE MATTER?

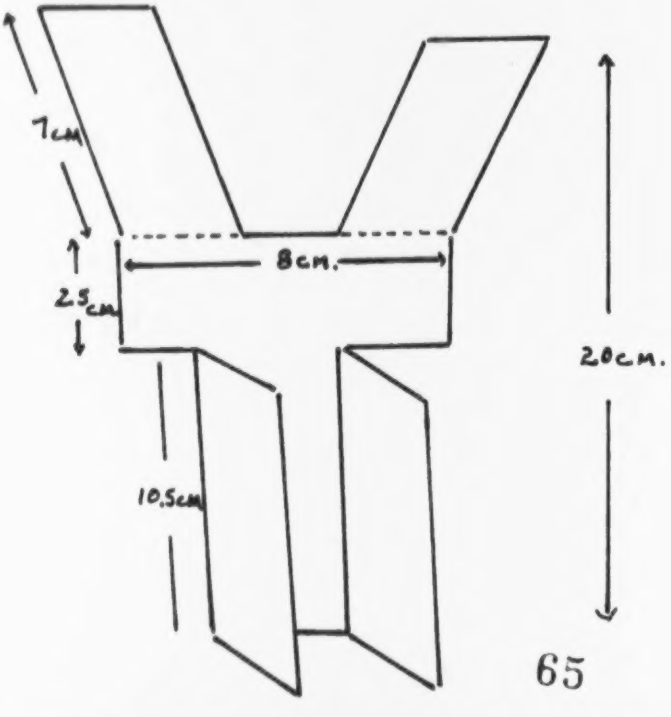
Objective: to demonstrate that the shape of an object can reduce air resistance.

Materials: Two pieces of construction paper for each student.

Procedure: Give each student two equal size sheets of construction paper. Ask students to notice the equality of the paper in size and weight. Crumple one and leave the other as is and ask students to do the same with their paper. On cue, have students drop both pieces of paper and notice which reaches ground first. Ask students to explain why one takes longer to fall when both are the same weight. (One has more surface area and must push more air aside as it falls). Ask students to think about air resistance and what kinds of shapes would stay in the air longer and what shapes would be more likely to fall faster. Ask what implications that has to airplanes, rockets, parachutes, kites, etc.

Using the figure at the bottom as a guide, have the students make whirlybirds. By tossing the heavy end into the air, students will see that air affects the whirlybird's fall.

Extension: Follow up with parachutes, paper airplanes, kites, etc.



SUBJECT:

Science

GRADE:

First

GROUP SIZE:

Large or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Student
Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Air resistance
Shape as variable
Evidence

SKILLS:

Observation
Comparison
Inference
Prediction

RESOURCES:

26, 31, 36,
49, 73

15

LIFT OFF

SUBJECT:
Science

GRADE:
First

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Air pressure

SKILLS:
Observation
Inference

RESOURCES:
26, 91, 298

Objective: to observe that air can be used as a force to do work.

Materials: Plastic bags (quart size for each child.) Two rather large tables. Student chair.

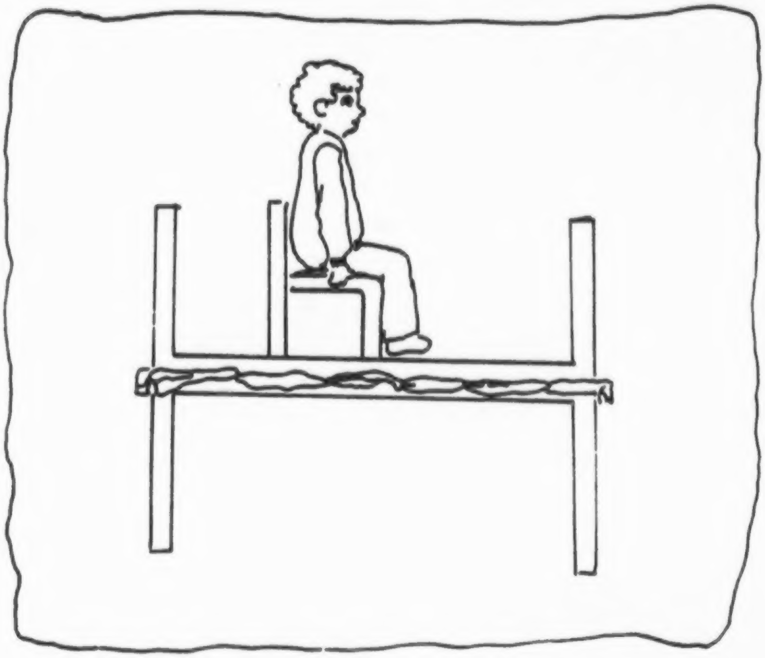
Procedure: Place approximately 20 plastic bags (number depends on size of table; bags should be approximately one foot apart) between the two tables - opening toward the outside. One table is to be turned upside down on top of the other table.

Have a student sit in the chair placed on top of the inverted table.

Station students one to a bag. On the count, each student is to blow into their bag. The air should lift the table.

Take turns with students in the chair.

Discuss what students notice as they do the experiment. Ask what conclusions they can draw from the experiment as it relates to using air to do work. Discuss how air does similar work in other places.



16

SAFE LANDING

Objective: To make and compare the effects of different parachutes on the speed of falling objects.

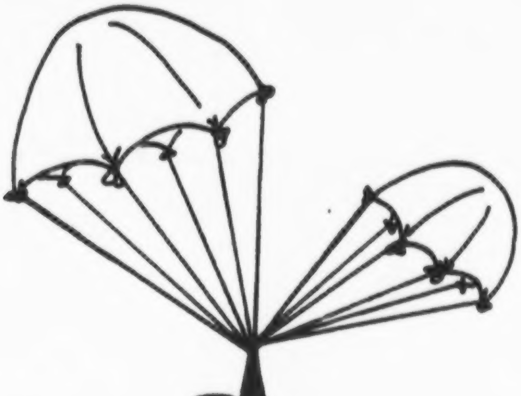
Materials: Cloth or handkerchiefs of different sizes. String. Small objects which can be tied to the string like erasers, tiny toys, pencils.

Procedure: Tie string to four corners of a square of cloth and then attach the other ends to a small toy or other object. Drop two similar objects from the same height, one with a parachute, the other without a parachute. Have the students observe which objects fall to the ground first.

Try two different size parachutes with the same weight. Which falls first?

Discuss the role the parachute plays in the safety of a person jumping from a plane or in the recovery of a space capsule.

Extension: Try different shapes of parachutes, multiple parachutes or parachutes of different materials.



SUBJECT:
Science

GRADE:
First

GROUP SIZE:
Large or Small

TIME:
45 minutes

TYPE OF ACTIVITY:
Student
Investigation

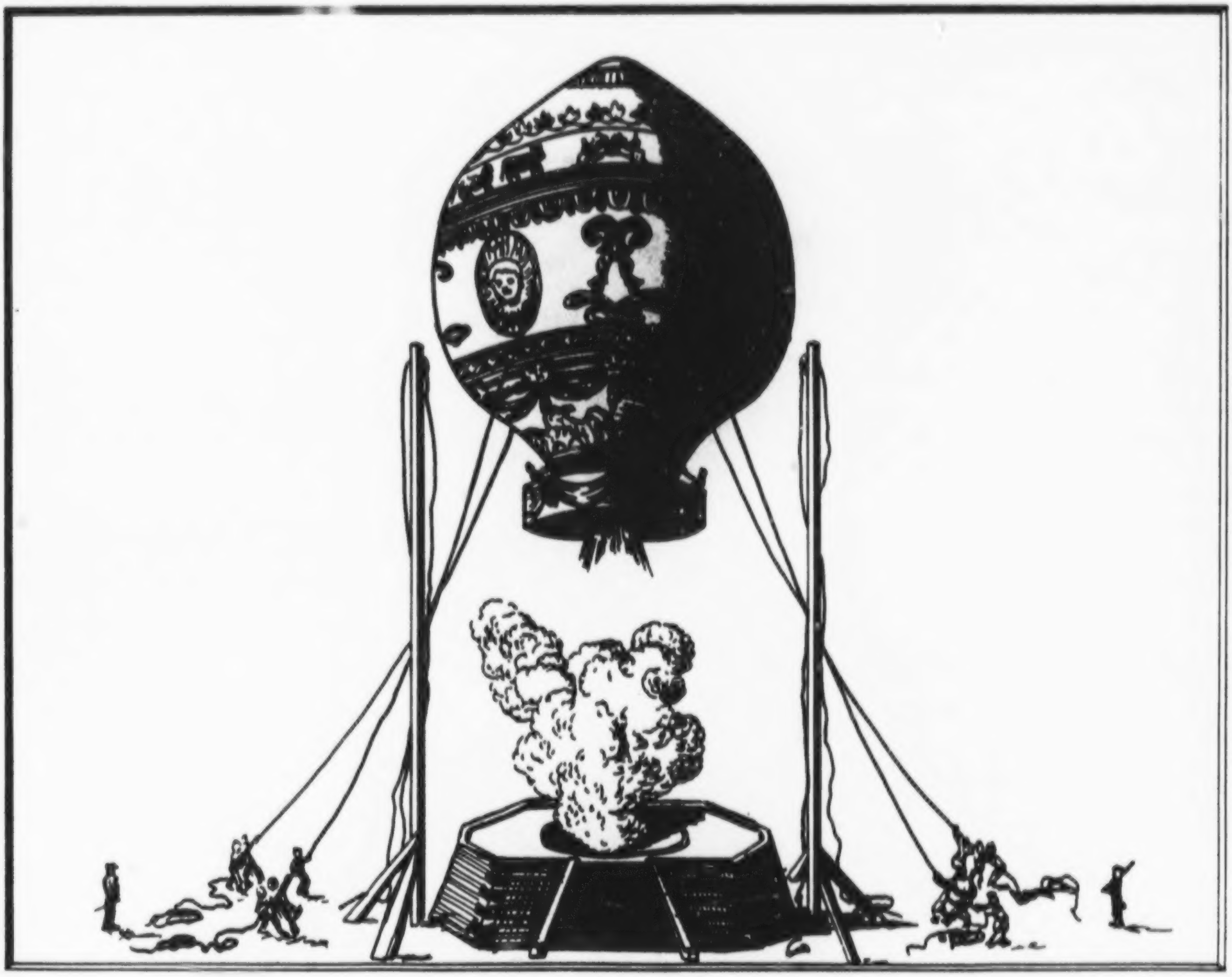
TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Parachutes
Slow Falling
Objects
Air Resistance

SKILLS:
Constructing
Models
Collecting Data
Hypothesizing

RESOURCES:
52, 69, 298

200 Years of Manned Flight



Nov. 21, 1783

Aeronauts d'Arlandes and de Rozier

in Montgolfier's Balloon near Paris

SECOND GRADE

"ABOVE THE CHIMNEY TOPS"

> "WE CAN LIFT OURSELVES OUT OF IGNORANCE, WE CAN FIND OURSELVES AS CREATURES OF EXCELLENCE AND INTELLIGENCE AND SKILL. WE CAN BE FREE. WE CAN LEARN TO FLY."
>
> RICHARD BACH
> JONATHON LIVINGSTON SEAGULL

17. BALLOONS THAT FLY - BALLOONS THAT DON'T
18. MOTION
19. GROWING A BALLOON
20. WHAT GOES UP MUST COME DOWN
21. UP, UP AND AWAY OR HOW TO BUILD A HOT AIR BALLOON
22. PAPER AIRPLANES
23. PAPER AIRPLANE GOLF
24. GLIDING HIGH
25. PARTS OF AN AIRPLANE
26. A VISIT TO THE AIRPORT

17

BALLOONS THAT FLY - BALLOONS THAT DON'T

SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Variables
Properties of Gases
Heavy/Light
Float
Interaction

SKILLS:
Observation
Identification of Variables
Inference

RESOURCES:
63, 70, 71, 298

Objective: To demonstrate that different gases affect the behavior of balloons in different ways.

Materials: Carbon dioxide (dry ice, which can be obtained from ice cream packing plant, to be handled with tongs only). Helium or helium-filled balloons. Balloons.

Procedure: NOTE: This is a demonstration by the teacher as students should not handle dry ice.

1. Using heavy gloves and tongs, insert a piece of dry ice into a balloon. Tie the top.

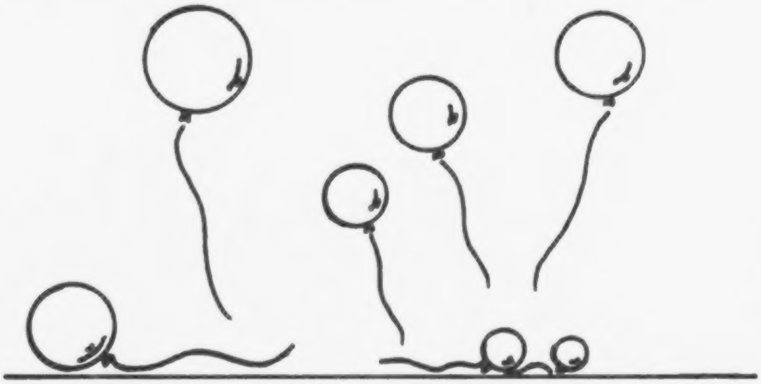
2. Have students blow air into their balloons and tie.

3. If you have a tank of helium available to you, fill a balloon for each student with helium.

4. Students will observe the carbon dioxide filled balloon expands and remains on the floor, the air-filled balloons will move about easily, remaining aloft briefly, the helium-filled balloons will quickly rise to the ceiling.

5. Ask how they think the gasses interact with the balloon. Note: Interaction is when something does something to something.

Extension: If you have enough helium-filled balloons for each student, attach a card to the balloon giving student's name and address and request the card be returned by mail giving location found. This will let the student know how far the air carried the balloon and the wind direction at the time the balloon was launched. (See Activity # 20).



18

MOTION

Objectives: to help students understand some of the causes of movement or motion; to develop the ability to differentiate between push and pull; to develop an understanding of the importance of air as a force.

Materials: Children's toys (ball, wind-up toy, spring toys, electric toys like cars, trucks, boats, model airplanes, rockets, helicopters, trains). Clamp-on roller skate. Plastic pail and water. Light-weight paper. Balloon.

Procedure: Start with a walk with the students to observe motion in every-day circumstances. Ask them to notice movement of papers, cars, leaves, swings, wires, water, animals, etc. Talk with them while on the walk about what they notice and when you return to the classroom ask them to recall what was seen and what caused the movement. Make an experience chart showing what they saw and what caused the motion.

Do some experiments with push-pull. Hold a ball straight out and let it fall. Ask what caused the ball to fall. Why did it bounce? (Force of gravity was not strong enough to cause it to stop immediately.) Have a student pick up an empty pail. Ask if it was easy to lift. What did she/he have to do to lift it? Fill pail half-full of water. Repeat. Ask student to tell what he/she noticed this time. Was it harder? Why? What was used to lift the pail? (Force from muscles. Energy from muscles to arm to hand to pail.) Throw ball up in the air. What was used to throw the ball up?

Examine toy cars, boats, airplanes, etc. Play with them. Ask how they move. How does the force operate? (Engines are the force on or in the cars, trucks, boats, etc. Wheels turn on the floor and push vehicle. Airplane propellers spin on the front of planes, push against the air and pull the plane through the air. Spinning boat propellers push on the water and pull the boat forward.)

Stand on skate and jump off. Notice the direction the skate moves in relation to the person's direction as he/she jumps off. Ask why this happens.

Do some experiments with the force exerted by air. Inflate a balloon and allow escaping air to push against a small pile of feathers. Why did they move? (Air became a force). Hold sheet of paper in front of mouth. Blow across paper. Observe lift of paper. Ask how paper moved. Ask where air should be directed to move or lift paper up. Where to move it down? Have children experiment to find answers.

Attach an inflated balloon to a toy car. Let air rush out of balloon. Why does the car move?

SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Large

TIME:
60 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Motion
Air as force

SKILLS:
Observation
Inference

RESOURCES:
29, 42, 44,
47, 298

19

GROWING A BALLOON

SUBJECT:

Science

GRADE:

Second

GROUP SIZE:

Large or Small

TIME:

30 minutes

TYPE OF ACTIVITY:

Experiment

TEACHING STRATEGY:

Expository
Guided Discovery

CONCEPTS:

Heat causes air molecules to move apart
Interaction
Energy Transfer

SKILLS:

Observation
Inference

RESOURCES:

63, 70, 71

Objective: to observe the expansion of air when heated.

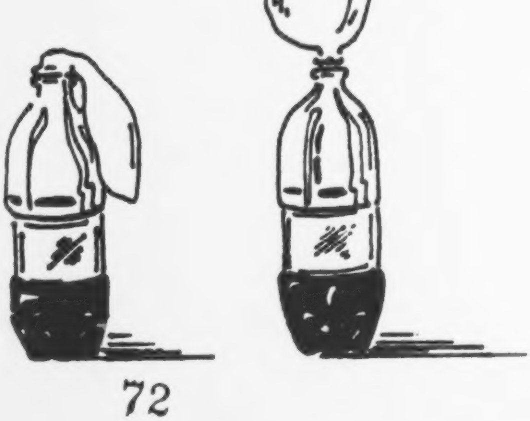
Materials: Balloons. Soda bottles.

Procedure: Distribute the bottles and balloons to each student or group of students. Ask them what is in the "empty" bottle or in the balloon. Have them smell the air in each. Look at the inside of each to see that nothing is there except air. You can talk with them about the air that they can feel in the balloon when they close it, trapping air inside. When they have discussed those characteristics of air and are quite certain there is nothing except air in either the balloon or the bottle, have them place the mouth of the balloon over the opening of the bottle.

If there is enough space near a sunny window, leave the bottles sitting in the sun until students notice change taking place. If it is winter when your heat source is on, you might place them near or over your hot air vent.

When the students notice the balloons are expanding, discuss the implication that holds for hot air ballooning. What might cause the balloon to expand? What happens when the bottle and balloon are put in a cool place?

Extension: Blow some soap bubbles or bring a burning candle flame near a hot radiator or other heat source. Let students observe the movement as the bubbles or flame are placed in different positions. When they note that the air above the heat source travels upward while the air near the floor moves downward, ask them to connect the "Growing a Balloon" activity to this and to hot air ballooning.



20

WHAT GOES UP MUST COME DOWN

Objective: to provide students with an understanding of air currents.

Materials: Helium-filled balloons (one per student). Stamped post card or index cards (one per student). String.

Procedure: 1. Have balloons filled with helium.

2. Each student should self-address postcard giving school address. On back of postcard, put information similar to the following:

EXAMPLE: This balloon was released ___(date)___
as part of a class experiment in
aerospace education. Please detach
and mail postcard after completing
this information.

Balloon was found (date)____________
at______________________________
(place)

by_________________________.

Thank you for helping.

3. Punch hole in top left-hand corner of postcard. Attach string (approximately six to eight inches in length. Tie securely to balloon.

4. When all balloons, cards, etc. are ready, they should be released in unison from open area around school.

5. As postcards are received back in mail, show location on area map using map pins with student's name attached. Give prize for balloon traveling farthest distance.

6. Discuss how the helium interacted with the balloon.

7. What interacted with the balloons to carry them to their ultimate destination?

Note: You may want to enclose postcard in a baggie just in case of rainy weather.

SUBJECT:

Science

GRADE:

Second

GROUP SIZE:

Large

TIME:

45 minutes

TYPE OF ACTIVITY:

Student Activity

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Air currents
Lighter than air
Interaction

SKILLS:

Collecting/recording data
Inferring

RESOURCES:

5, 15, 63

21

UP, UP AND AWAY
OR
HOW TO BUILD A HOT AIR BALLOON

SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Large or Small

TIME:
2 hrs to construct
45 min. to fly

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository

CONCEPTS:
Hot air rises
Lighter than air flight
Energy transfer

SKILLS:
Observation
Inference

RESOURCES:
63, 70, 71, 298

Objective: to demonstrate that hotter air rises; to demonstrate lighter than air flight.

Materials: 4 packages of art tissue paper (in various colors if you like). Rubber cement and brush. Light wire (approximately 110 cm.). Scissors, pencil, string and a long pole.

Teacher Background Information: A significant property of a gas is its expansion when heated and contraction when cooled. A mass of hot air is less dense and therefore buoyant in a mass of cold air. If the mass of hot air is contained in a lightweigh balloon, the hot air will impart lift to the balloon. The principle can be demonstrated in this activity.

This activity can go on for some time depending on how involved the students are with the construction, designing, and testing of a balloon that really does what they want. Kits are available, but the construction and redesigning can be more valuable for students.

NOTE: Whenever you use an open flame, keep a fire extinguisher nearby and follow common sense rules for safety. If you have grave concerns about using flame, you can use a hair dryer for your source of hot air, although they usually do not provide sufficient hot air for a flight of any satisfactory duration or altitude.

Procedure: 1. Cut tissue into 20 sheets 50cm. by 150 cm. Join pairs end to end to give you 10 sheets 50 cm. by 300 cm. (See directions on page 62)

2. Arrange the 10 sheets one above the other in the desired color sequence. Trace a pattern like the one shown on page 62, #2.

3. Cut out the pattern through all 10 sheets at the same time.

4. Glue one edge of the top sheet to the same edge of the sheet below (See step 1). Glue the other edge of the second sheet to the third sheet. Continue until all are glued then glue the top sheet to the bottom sheet.

5. Tie the top leaving a loop. Inflate using a fan.

6. Enclose a wire hoop at the botton of a fold of the lower edge. Attach two nylon strings (about 160 meters long) to use to guide, if necessary, the balloon in flight.

7. Suspend about 30 cm. above a Coleman type stove using a long pole. When the balloon is fully inflated, remove the pole. The balloon will rise quickly to an altitude of about 150 meters.

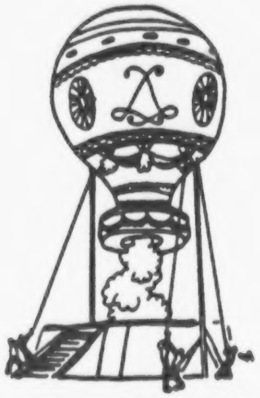
Discuss the transfer of heat energy from the source to the air in the balloon.

NOTE:

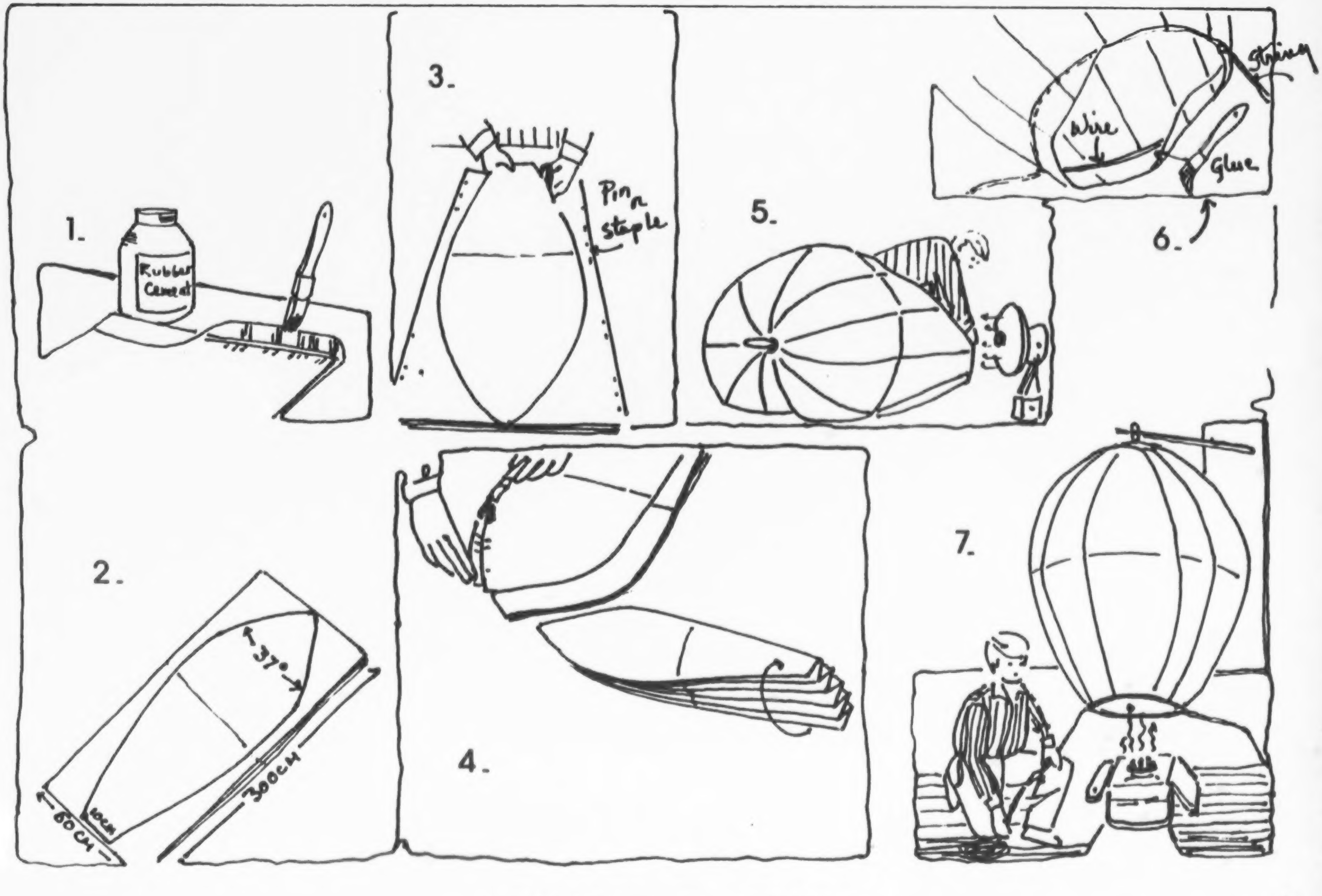
The hot air balloon should be flown outdoors only, and with adult supervision. Fly on a windless day. Conditions for flying are also better in colder weather--winter or early morning.

Other things to do with hot air balloons:

1. Make a scale model/drawing.
2. Determine the height it can attain.
3. Determine how much it can lift?
4. Determine whether the outside temperature affects it's lift.
5. Determine how hot the inside air gets.
6. Determine what material is best for making a balloon.
7. Determine best (efficient and safe) method to use for heat source.



Montgolfier balloon



— building a balloon —

22

PAPER AIRPLANES

Objective: to demonstrate that various airplane designs will result in different flight principles.

Materials: Flat paper sheets (scrap paper), Paper clips (for balance). Cellophane tape. Glue or stapler.

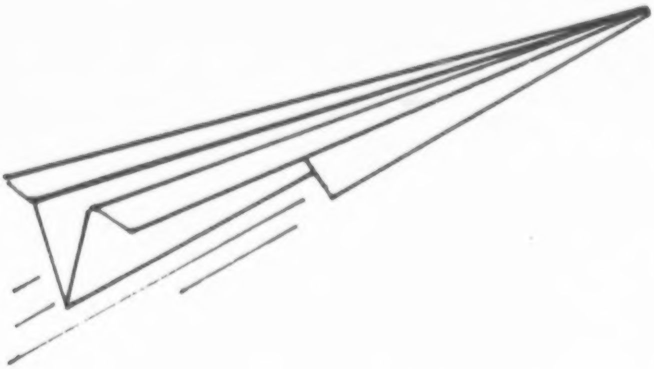
Procedure: Have the students fold an airplane of their own design. Ask the students to test fly their planes for such things as accuracy, duration or acrobatics. Have them modify their designs if they feel it is necessary.

When they are ready, participate in the following contest:

a. Accuracy: Winner must fly the farthest along a straight line.
b. Duration: Winner must stay aloft the longest.
c. Aerobatic: Winner must perform a maneuver named by the student before he/she launches it.

Award prizes to winners in each category and discuss why the winners' planes worked as well as they did and why some others worked less well.

Discuss how the planes were set in motion. Where does the energy come from? What interacted with the planes?



SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Student Activity

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Design variables
Flight principles
Energy Transfer
Interaction

SKILLS:
Design/Construction
Testing/Modifying

RESOURCES:
30, 36, 298

23

PAPER AIRPLANE GOLF

SUBJECT:

Science

GRADE:

Second

GROUP SIZE:

Small or Large

TIME:

45-60 minutes

TEACHING STRATEGY:

Guided Discovery

TYPE OF ACTIVITY:

Game

CONCEPTS:

Variables
Wind
Air
Change
Interaction

SKILLS:

Observing
Describing
Measuring
Manipulation of variables

RESOURCES:

30, 35, 36

Objective: Discover variables which affect the flight of a paper airplane; Discover that changes in the configuration of a paper airplane affect flight.

Materials: Sheets of 8½ x 11 paper (used is OK).

Teacher Background Information: This game, similar to "Frisbee" golf, is played with paper airplanes. Resist telling the students what they should be finding out during the activity and encourage them to explore which variables affect the flight of their airplane.

Procedure: Number the cans from 1-9 and place them outside from 10-50 feet apart. Have the children fold paper airplanes and, starting at a point about 15 feet from the first can, throw the plane toward the can. The object of the game is to get the plane into each can with as few throws as possible.

Have the students discuss what factors seemed to affect how accurately their plane flew. Encourage the students to invent ways to make their plane fly better so they can lower the number of throws required to get them around the course.

Extensions: You may wish to enlarge the course or design it so there are hazards as the students improve on their planes. Some students may want to fly their planes indoors to control for the variable of wind and then move outdoors.

Try graphing the results of the flight of different designs.

Measure distances in meters or feet.

Explore the effects of the wind on other objects like balloons or clouds, for example.

24

GLIDING HIGH

Objective: to learn that changing movable parts of an airplane changes the flight pattern.

Materials: Outline of glider (next page). Light cardboard. Paper clip.

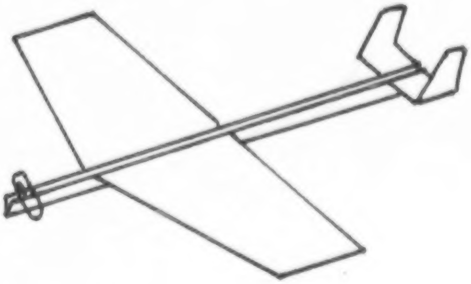
Procedure: Have students make a copy of the diagram with tracing paper.

Distribute a folded piece of thin cardboard to each student and have him/her trace the diagram on it, placing the long straight line on the folded edge.

Cut along the traced line. Bend the wings and tail as indicated.

Using drawing B., outline the ailerons, rudders and elevators. Cut along the solid lines and score the dotted lines.

The finished glider should look like this:



Try each of the following and find out what the glider does:

a. Bend both rudders right.
b. Bend both rudders left.
c. Bend both elevators up
d. Bend both elevators down
e. Bend the right aileron up and the left one down.
f. Bend the right aileron down and the left one up.

What conclusions can the students draw from the results? Do they use the terms "Interaction," "Energy transfer," or "Variable?" They should have enough background in those concepts, if they have done the previous lessons, to begin to use the terms and concepts to draw new conclusions.

Suggestion: It might be helpful, as the students construct their glider, to have them use page 74 (The Main Parts of an Airplane) as a reference of a more complicated model. Students should be better able to "see" how their model, and its parts, corresponds to a small plane.

SUBJECT:

Science

GRADE:

Second

GROUP SIZE:

Large or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Changes
Flight path
Variables
Interaction
Energy transfer

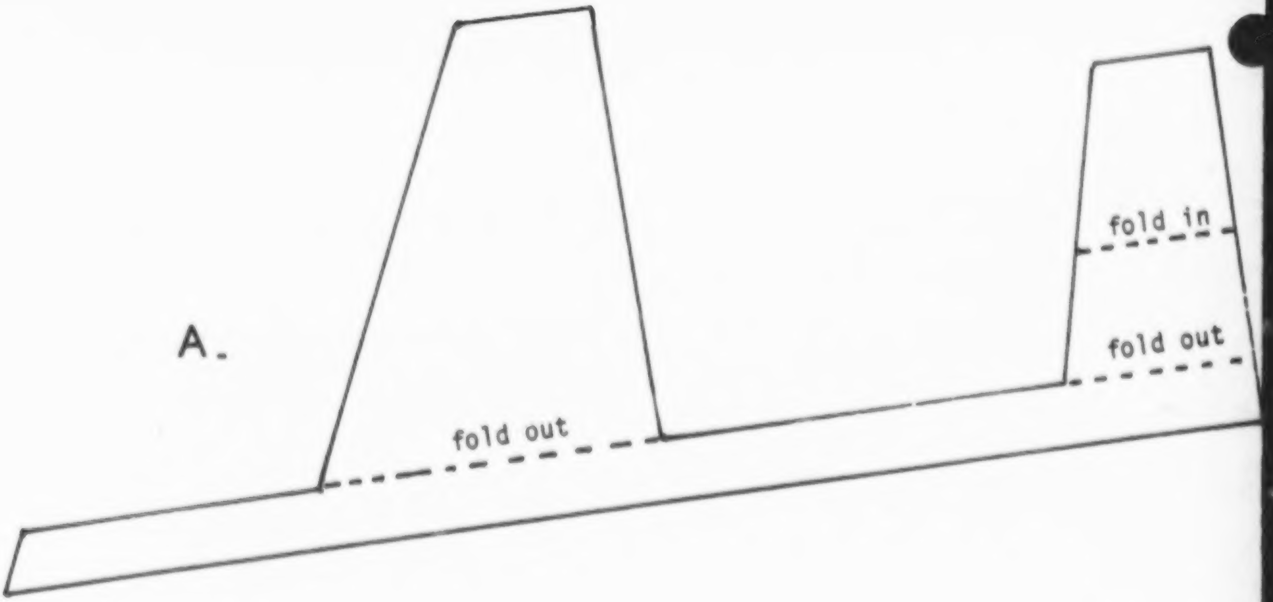
SKILLS:

Experimentation
Observation

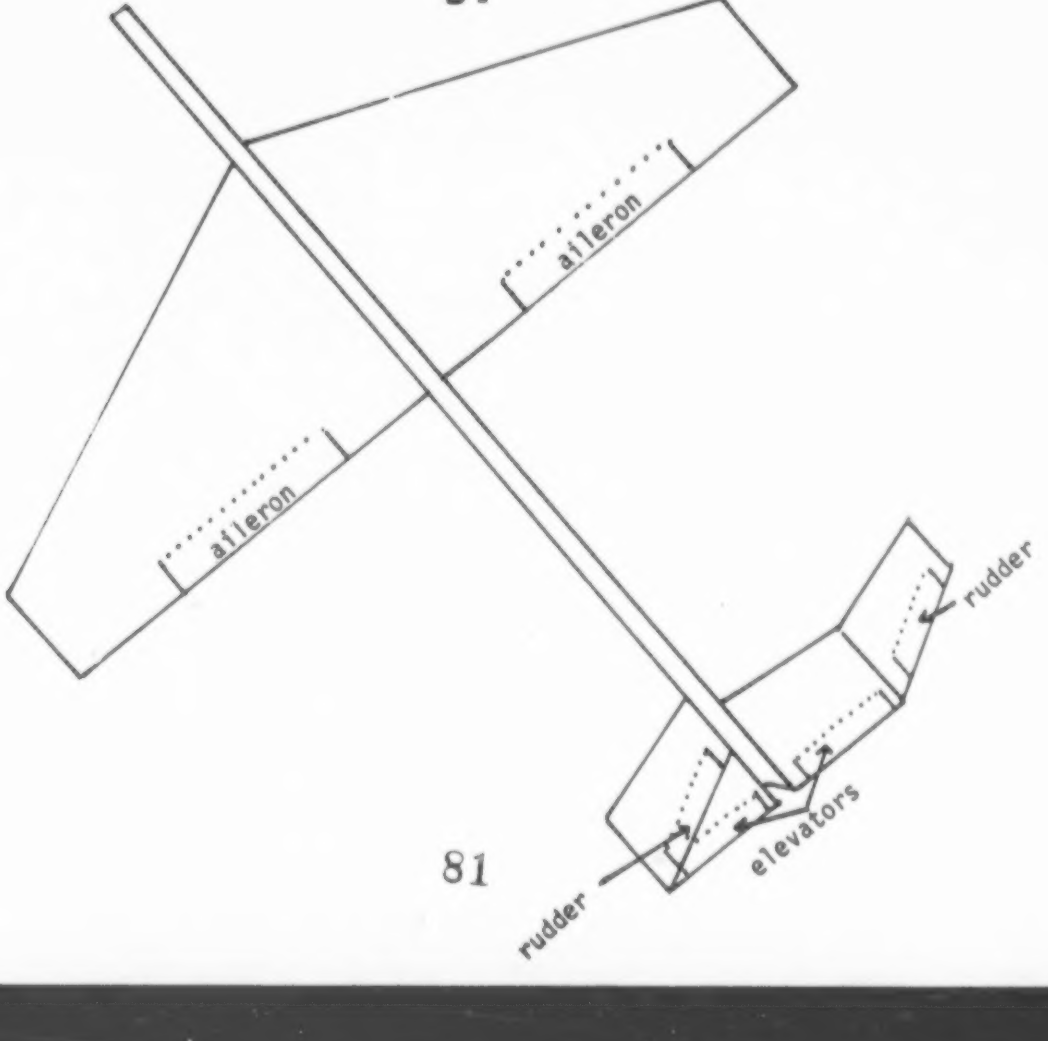
RESOURCES:

26, 31, 37, 38,
47, 49, 51, 52

A.


fold in
fold out
fold out

B.


aileron
aileron
rudder
elevators
rudder

25

PARTS OF AN AIRPLANE

Objectives: to learn the names of various parts of the airplane; to give operational definitions for those parts.

Materials: Worksheets (following two pages). Crayons. Glue. Cardboard. Scissors. Assembled plane to use as model.

Procedure: Assemble a plane from the outline. Do not color it but use it when you and students look for the various parts to color as a model of the completed plane.

Distribute the worksheets with plane parts and definitions. Ask the students to go through the worksheet of definitions with you. Read the definition and focus on what the part (system) of the plane does as well as its name and where it is located. After the class has found the specific part, have them find the appropriate color and color the part just discussed. Do each one with them and monitor the accuracy so they don't get confused later. Take it slow.

Discuss the concept of systems with them. Explain that the airplane is a system composed of sub-systems. Ask what they might be (wings, tail, fuselage, landing gear, etc.). Explain that sub-systems often have their own sub-systems like the tail which is made up of the rudder, horizontal stabilizer and the elevator. (These have sub-systems too, but that's for later.)

When the students have finished finding the parts and coloring them in, have them paste the paper pieces to cardboard. Have them cut out the pieces and assemble their own planes. Fly them. Hang them as mobiles. They're VERY colorful and having them around keeps the names and definitions of the parts in mind.

Extensions: If the students would like to, you can make up more outlines to cut out and paste onto cardboard but before assembling, students can score along the lines that would allow the movable parts to move appropriately: the flaps to move down, the ailerons to move up and down, the rudder to move side to side, etc.

The students could make their own design in the same way, changing wing configuration or elongating the fuselage, etc. Have them take into account, however, the basic parts of the airplane in their own designs.

SUBJECT:
Science

GRADE:
Second

GROUP SIZE:
Large

TIME:
60 minutes

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Definitions
Systems
Sub-systems

SKILLS:
Observation

RESOURCES:
38, 41, 42, 43

PARTS OF AN AIRPLANE

FUSELAGE	Central body portion of airplane. Designed to carry the crew, passengers or cargo.
COCKPIT	Usually the space in the fuselage for the pilot and passengers; in some aircraft it is the pilot's compartment.
PROPELLER	A rotating blade on the front of the plane. The engine turns the propeller. The propeller most often pulls the plane through the air.
WINGS	The parts of the plane which provide lift and support the weight of the plane and its passengers, crew and cargo while the plane is in flight.
FLAPS	Movable sections of the plane's wings closest to the fuselage. They move to enable the plane to fly more slowly.
AILERONS	Moveable sections of the planes's wings found on the outer part of the wing. They move in opposite directions (one up and one down) and are used to make turns. (bank)
RUDDER	The movable (vertical) section of the tail which controls lateral (side) movement. (Right & Left)
HORIZONTAL STABILIZER	The horizontal stabilizer is the horizontal (level) surface of the rear part of the fuselage. It is used to balance the airplane.
ELEVATOR	The moveable horizontal section of the tail which allows the plane to move up and down.
LANDING GEAR	Located underneath the plane, it allows the plane to land and supports it while on the ground.

Color the parts of the airplane pieces as follows:

FUSELAGE - White

COCKPIT - Black

PROPELLER - Brown

WINGS - Yellow

FLAPS - Blue

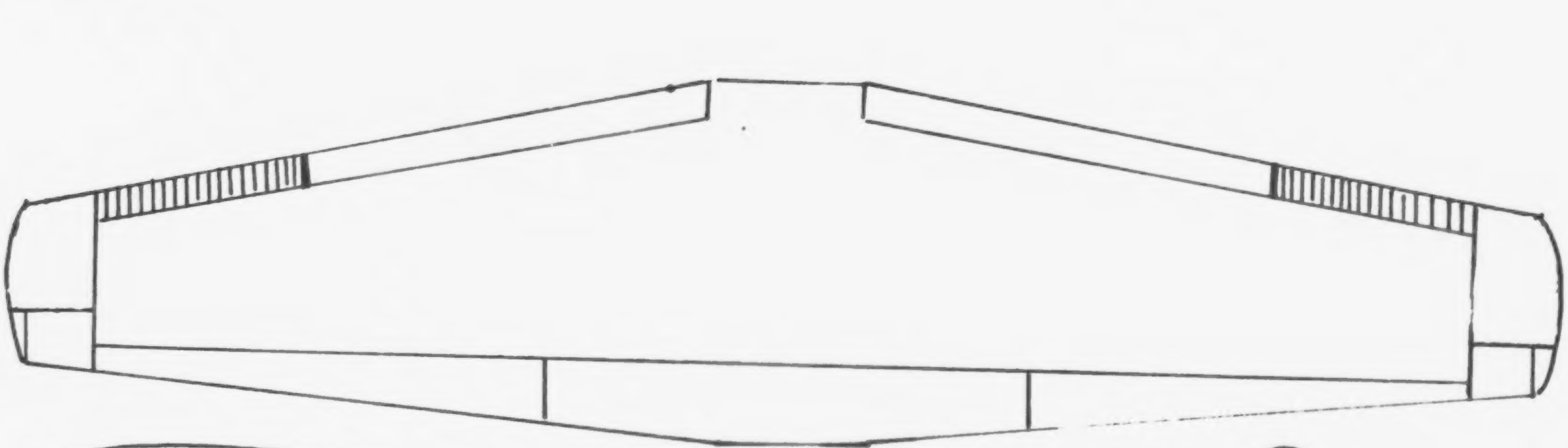
AILERONS - Red

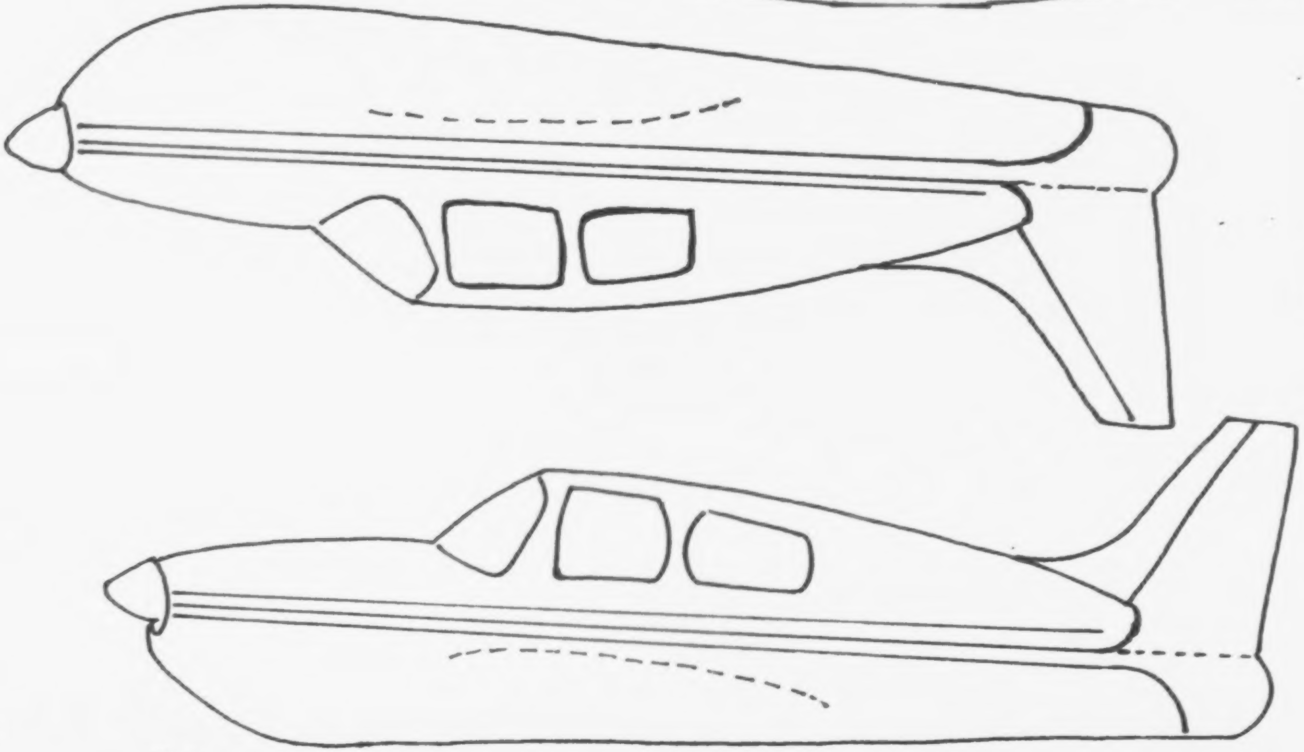
RUDDER - Purple

HORIZONTAL STABILIZER - Orange

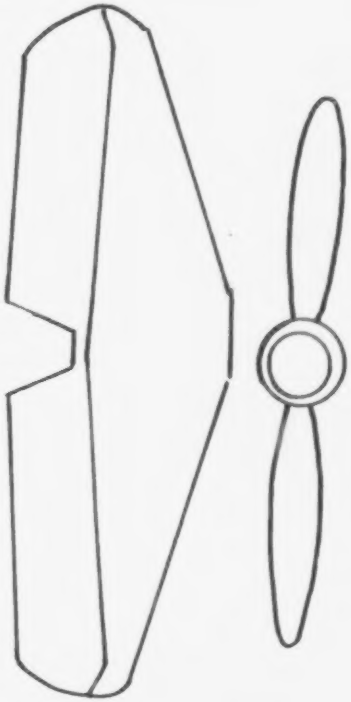
ELEVATOR - Green

Where's the LANDING GEAR when a plane is cruising along? Where can a plane land? On what?





84



85

26

A VISIT TO THE AIRPORT

Objectives: to understand the airport is a system made up of sub-systems; to learn about some of the jobs at the airport.

Materials: "Stuff" to prepare children cognitively and affectively prior to trip: "A Trip to the Airport," (a booklet from US Department of Transportation. Story books on airports and airplanes. Model airplanes, gliders, etc. Pictures of airplanes and airports. Model airport.

Teacher Background Information. This activity can be one of the most exciting experiences for students, especially if it is planned well and children have participated in a lot of aviation activities that have given them the chance to anticipate what they will do and see.

Arrange the trip with the public relations department of the nearest large airport or the Public Relations Department of one of the airline companies. Get plenty of adults to accompany the students and, if they can, have them in to the classroom before the trip to talk with the students about what they're going to see.

Procedure: Discuss with the students, what goes on at an airport. Ask if they've been to one. What did they notice? What would they like to see when they go? After you have made arrangements tell them they will be seeing such things as: A) People working at LOTS of different jobs. Talk about some of them (pilot, flight attendent, porter, truck driver, food service person, flight controller, mechanic, etc.

B) Airplanes--a big one and a smaller one they can examine.

C) The different parts of the plane they learned about.
D) The inside of a plane: Cockpit, galley, seating, etc.
E) An instrument panel
F) The control tower
G) A hanger
H) Runways
I) The terminal

Ask what they know already about some of these things? What would they like to know?

Collect story books about the airport and airplanes. Read to the students the ones that are beyond their reading level and let them read the others themselves. Arrange an aviation center in the room where the books will be kept.

SUBJECT:

Science

GRADE:

Second

GROUP SIZE:

Large (grouped with adult aides)

TIME:

Day-long trip

TYPE OF ACTIVITY:

Field Trip

TEACHING STRATEGY:

Open Discovery
Guided Discovery
Expository

CONCEPTS:

System
Sub-system
Airport jobs

SKILLS:

Observation
Participation
Investigation

RESOURCES:

111 thru 129

especially 123

Make a flying bulletin board--pictures, maps, paper gliders and airplanes, etc.

Hang model airplanes and helicopters from the ceiling.

Build a model airport on a table top complete with runways, hanger, tower and model planes.

Do the other activities in this section of the Guide before you go.

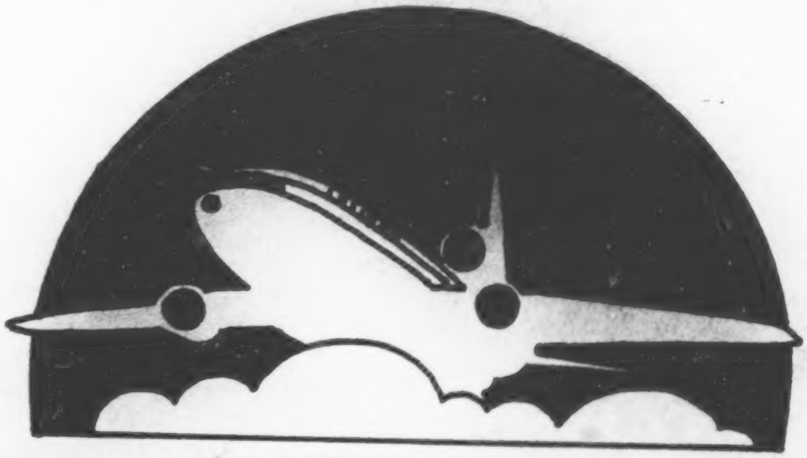
Go and Enjoy.

Afterward, have students write about the experience. Have them illustrate something that especially interested them with a drawing or collage. Have them write thank you's to the appropriate people.

Have students add to the model airport, the people and things they hadn't been aware of before. Create a bulletin board of pictures and drawings showing workers at the airport. Discuss who's in charge at the airport (The system) and some of the different parts (sub-systems) that make up the whole airport.

Take an imaginary trip to a city the class chooses and put, in order, the steps one would go through and what one would see along the way. Start with arranging for tickets and end with getting into a taxi at the terminal in the distant city or being greeted by relatives in the baggage area. Make a story out of it.

Plot the miles to the distant city. Find out how much fuel a 747 uses per mile and how much it would use to get there. Find out the cost for jet fuel and compute.



"BIRDS FLY - WHY CAN'T I?"

> "GREAT SCIENCE IS CONCEIVED AT THE BOUNDARY WHERE EXACT OBSERVATION CONFRONTS LEAPING IMAGINATION."
>
> H. F. JUDSON, AUTHOR
> SEARCH FOR SOLUTIONS

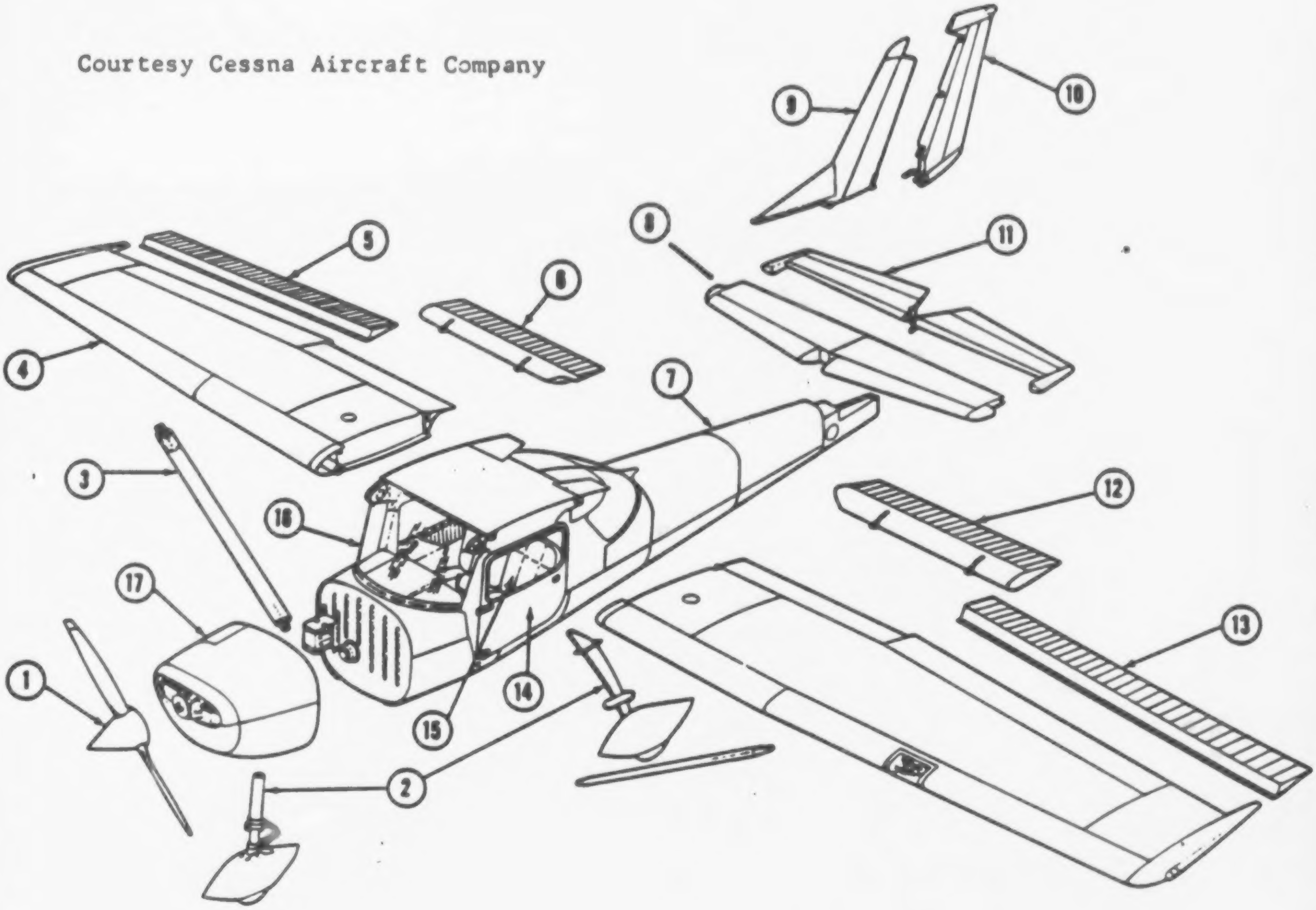
27. THE FOUR FORCES OF FLIGHT
28. MEASURING THE FORCE OF GRAVITY
29. GO FLY A KITE
30. MORE WITH MODEL AIRPLANES
31. JET ENGINE THRUST
32. WHAT DO YOU KNOW ABOUT THOSE FUNNY FORCES?
33. WILD AND CRAZY ROCKET MODELS
34. CONSTRUCTION OF AN ACTION-REACTION MODEL
35. ROCKET PROPULSION I
36. ROCKET PROPULSION II
37. BOOM!
38. WEATHER PICTURES
39. SIMPLE WIND VANE
40. SOCK IT TO ME!
41. MEASURING THE WIND
42. TEMPERATURE TAKING TIME
43. WEATHERPERSON FOR A DAY
44. WEATHER CENTER

SPECIAL REVIEW SHEET...

To the Teacher:

Before you begin the series of activities on how an airplane flies, you might want to review the main parts of the airplane learned in Grade 2. The following can be used for such a review and includes a number of parts not previously mentioned.

Courtesy Cessna Aircraft Company



The Main Parts of an Airplane

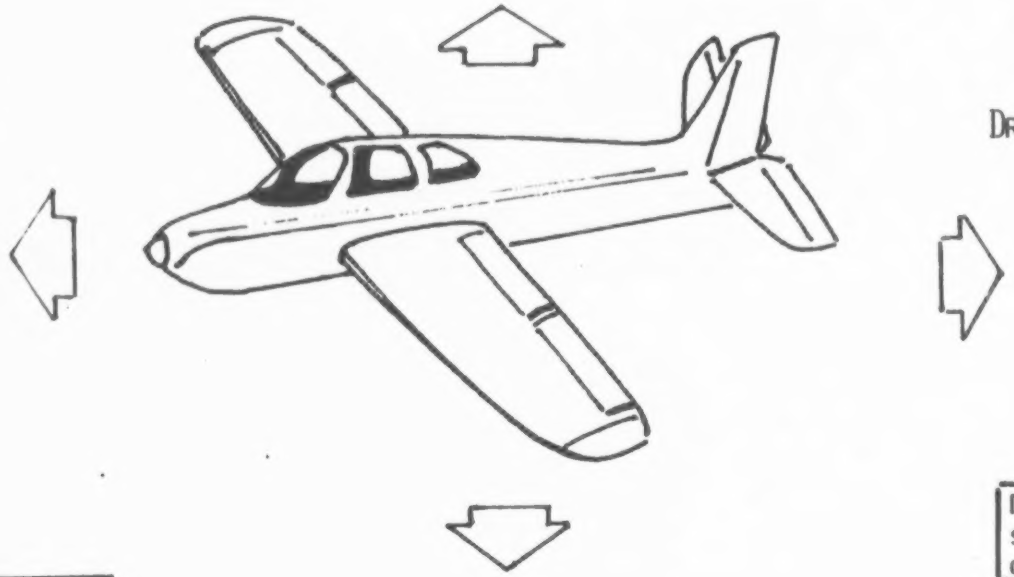
1. **Propeller**
2. **Landing Gear**
3. **Wing Strut**
4. **Wing**
5. **Right Wing Aileron**
6. **Right Wing Flap**
7. **Fuselage**
8. **Horizontal Stabilizer**
9. **Fin and Dorsal**
10. **Rudder**
11. **Elevator**
12. **Left Wing Flap**
13. **Left Wing Aileron**
14. **Door**
15. **Seat**
16. **Windshield**
17. **Engine Cowl**

LIFT is an upward force that acts against gravity because of a partial vacuum created above the surface of an airplane's wing causing the wing to be "lifted" upward.

Lift is produced by (a) the difference in the speed of air flowing over the wing surfaces and (b) the angle of attack.

Thrust may be produced by engine-driven propellers, jets or rockets.

THRUST is a force created by a power source which gives an airplane forward motion.



DRAG is the resistance the air offers because of friction which slows the forward movement of an airplane through the air. It is a backward force that works against thrust.

Drag may be reduced by streamlining the shape of the plane.

The weight of the airplane is produced by the attraction of gravity.

GRAVITY is a force which pulls downward on the plane.

— THE FORCES INVOLVED IN FLYING A PLANE —

27

THE FOUR FORCES OF FLIGHT

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Small or Large

TIME:
4-60 minute
periods

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery
Expository

CONCEPTS:
Gravity
Thrust
Drag
Lift

SKILLS:
Observation
Measuring
Experimentation

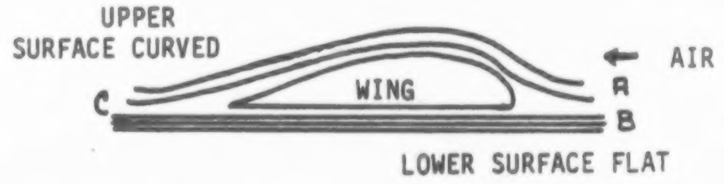
RESOURCES:
26, 42 - 46,
48, 52

Objective: to introduce students to the concept of drag, thrust, gravity and lift.

Materials: Worksheet (see preceeding page.)
For Lift. Sheets of paper. Books. Drawing of air-flow over and under airplane wing. String. 2 ping pong balls. Ruler and index card.
For Gravity. A student. Pencil, rock, ball. Jump rope. Ruler and paper clip. Marbles. Rubber band.
For Thrust. Fan. Small Wagon. 2 long balloons. Lightweight toy. Straws. Lightweight wire.
For Drag. Piece of cardboard. Umbrella. Paper. Marble. Aluminum Foil. Clothes Pin. Catsup bottle cap.

Procedures: Discuss with students the notion that people had to wait until they could design an aircraft with sufficient power, lift and stability before a heavier-than-air craft could be developed. Discuss the four forces that act upon a plane flying in the atmosphere: Lift, gravity, thrust, and drag, and use the worksheet with the explanations on it for reference. In order to give students the opportunity to observe these forces, do the following experiments with them.

LIFT. 1. Prepare a bulletin board showing how air flows over and around an airplane wing. Use for reference.



2. Have students hold a piece of paper just below the lower lip. Ask them to blow across the top and observe that the paper rises as the pressure on the top of the paper is reduc by the movement of the air.

3. Suspend a length of paper loosely between two piles of books. Blow across the top of the paper. What happens?

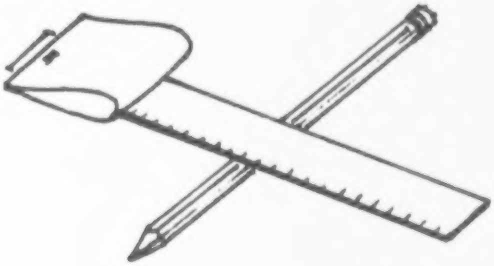
4. Suspend two sheets of paper about 2.5 cm (1") apart between two stacks of books. Blow between the sheets of paper. Notice what happens. (Papers come together.)

5. Use lightweight string or thread to suspend two ping-pong balls about 2.5 cm apart. Using a straw, blow between the two balls. What happens? Why?

6. Pull a strip of paper through the air. Observe what happens. Ask why they think it happened.

7. Push a sheet of paper forward through the air and observe the paper rise as it pushes against the air. Discuss why.

8. Tape or tack an index card to a ruler so that it curves like an airplane wing. Balance ruler on a 6-sided pencil with the card end slightly lower. Using a straw, blow across the curved surface of the card. Notice what happens. Why?



Extension: Have students do some reading on Bernoulli and how Bernoulli's principle came to be.

GRAVITY. 1. Ask one of your students to jump into the air and stay there. Discuss why she or he can't do that. Discuss what would happen without gravity.

2. Drop a pencil, rock and a ball. Discuss why they come down.

3. Have a student jump rope. Discuss why the rope can be "turned."

4. Compare the speed of fall of two objects of identical size and shape, but different weight.

5. Observe the change in the speed of an object (a paper clip) rolling down an inclined plane (a ruler) as the angle of inclination is increased or decreased. What implication does that hold for planes and rockets taking off?

6. Do the Activity "Measuring the Force of Gravity."

THE FOUR FORCES OF FLIGHT (continued)

THRUST. 1. Place a fan in a small wagon. Ask students to notice the movement of the wagon when the fan is turned on. What direction does the wagon move?

2. Have students blow up balloons and hold the opening tightly closed. Ask them to release their hold on the opening and notice what the air feels like on their hand as the balloon is released. What direction does the air move in? What direction does the balloon move in? Why, when it has released all its air, does it fall?

3. Fasten an inflated balloon to a small, lightweight toy so that when air is released, the toy will move forward. What direction is the air moving in?

4. Discuss Newton's Third Law of Motion: "For every action there is an equal and opposite reaction." Discuss what made the balloon go in a specific direction. What makes it go up? Is anyone moving the balloon? How does the balloon change after it is released? What happened to the air in the balloon? What does Newton's Third Law have to do with airplanes and rockets?

5. Do the Activity "Constructing an Action-Reaction Engine."

Extension. Have students do some reading on Newton and his Third Law of Motion. Encourage them to experiment with action-reaction with you and the class.

DRAG. 1. Have students run with a large square of lightweight cardboard held flat against the wind. Repeat with the edge against the wind. Observe the difference in the amount of resistance.

2. Give student a closed umbrella. Have her or him hold the umbrella behind and run. Observe the amount of drag on the umbrella. Open the umbrella, hold it behind and run quickly. How does the amount of drag change? Ask students to think about why.

3. Drop, at the same time, two identical sheets of paper one flat, one crumpled. Observe the effect of air resistance on the rate of fall. Why?

4. Drop a sheet of aluminum foil and a marble at the same time. Crumble the foil into a ball, and again drop the foil and marble at the same time. What happens?

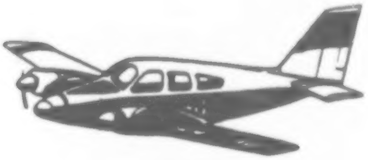
5. Drag a clothespin through water, then attach a catsup bottle cap to it and notice the additional drag.

6. Discuss the shape of the objects used and compare the results on drag with the various shapes. What implications does this have on the design of airplanes?

7. Walk on surfaces of varying degrees of roughness (rough cement, wooden floor, highly polished surface, ice). Observe that walking is easier when there is something rough to push against. If there is too much resistance, it becomes more difficult. Discuss walking on a wet, sandy beach.

8. Cut a 1" square cube out of wood. Cut 1" square pieces of various materials: cloth, aluminum foil, leather, rubber, sandpaper, styrofoam. Glue the pieces to the six sides of the cube. Set cube on a very smooth board and incline the board until the cube begins to slide. Measure the distance between table top and board. Repeat with all sides of the cube and compare the incline necessary to cause the cube to slide and see the variable that makes the differences. Talk about resistance to motion when surfaces are rubbed together (friction). Graph the results of the experiment. Discuss the implication this has to the material used for airplanes.

9. Do the Activities "It's a Hold up," "Does Shape Matter?" and "Safe Landing" in the First Grade Section of the Guide.



28

MEASURING THE FORCE OF GRAVITY

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Student Investigation
Discussion

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Gravity
Weight as measure of pull

SKILLS:
Observation
Recording data
Prediction

RESOURCES:
153, 298

Objectives: to help student understand weight as a means of measuring the pull of gravity; to help students understand the relationship between gravity and flying; to understand a spring scale measures the pull of gravity on an object.

Materials: Pictures showing gravity at work. A strip of inner tube or very strong elastic. Shelf paper and marking pen. Scale. Various materials of different weights. Plastic pail. Hook.

Teacher Background Information: Hang long piece of shelf paper on wall and attach large hook at the top. Gather several materials of differing weights such as sand, water, chalk, cotton, etc. Tie strip of tubing around the handle of the pail and hang on the hook.

Procedure: Begin with discussion on children's concept of gravity. Drop object to floor and ask students what they notice and why it happens. Pour liquid into a glass. Ask why it doesn't fly out the open top.

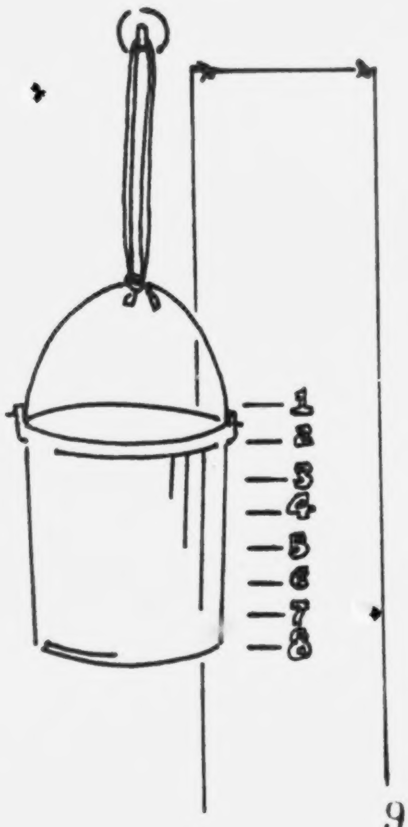
Show the pictures of gravity at work (sledding, liquids contained, people standing on the earth, etc.) Discuss what is happening in the pictures and why.

Experiment with the students. 1. Fill the suspended pail with one of the heavier materials such as sand. Have a student make a mark on the shelf paper where the pail falls. Write "sand" at that mark.
2. Empty the pail and have students choose another material. Ask them to predict what will happen. Fill pail with second substance and mark where pail falls.
3. Choose a third and ask students to predict how the weight of this material will compare to the other two. Fill pail and repeat procedure.
4. Continue until all the materials have been measured. Which material is acted on by gravity the most? Which the least? Ask how this information relates to flying. Ask how they might be able to measure the actual force of gravity pulling down on each kind of material. (Weigh the pail; weigh the material in the pail; subtract the weight of the pail.) Collect the data and record on charts. Discuss the idea that the pull of gravity is equal to the weight of the object-that weight is a product of gravity.

Extensions: Ask each student to record the force of gravity acting on her or him. How? Explain they can determine their weight on the moon by dividing their earth weight by six. Ask them to do so. Ask why they weigh less on the moon than they do on earth. Ask them to make a chart that compares their earth weight to their moon weight. Discuss what they might do on the moon that would be difficult or impossible on earth.

Make a trip to the library for books on experimenting with gravity. Let students choose those that are appropriate to do in the classroom or outdoors. Do some.

Have students calibrate the homemade spring scale before you use it by choosing some small common object to use as a standard (nails, washers, bolts, etc.) After the pail has been attached to the tubing, drop in one of the standards and mark where the top of the pail comes. Add a second and mark, a third and mark, etc. Have students print a "0" where the pail came without any standard in it and then continue marking 1 through whatever length is required. Have them put in the different materials and compare the results in the standard units they have chosen.



29

GO FLY A KITE

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Any

TIME:
40 minutes

TYPE OF ACTIVITY:
Construction

TEACHING STRATEGY:
Expository and Guided Discovery

CONCEPTS:
Lift
Balance

SKILLS:
Gathering data
Interpreting data
Identification of variables

RESOURCES:
33, 75, 83

Objective: to practice gathering and interpreting data relative to flight; to discover the principles of balance and lift related to the flight of a kite.

Materials: one or more of the kites described on the following two pages.

Procedure: Any of the following investigations can be used to explore variables affecting the flight of a kite or they can be used to emphasize process skills. Don't forget to have fun.

1. Measure how quickly several kites reach a given altitude when flown together. Which designs climb farthest? fastest?
2. How does the placement of the "harness" on the kite affect the flight?
3. Is balance (a tail) needed on some models during different weather conditions?
4. Graph the results of several experiments. Is there one overall best design?

NOTE:

Remember: NEVER use wire for kite "string."

NEVER climb power poles to try to retrieve a kite.

NEVER fly kites during electrical storms.

"GO FLY A KITE"

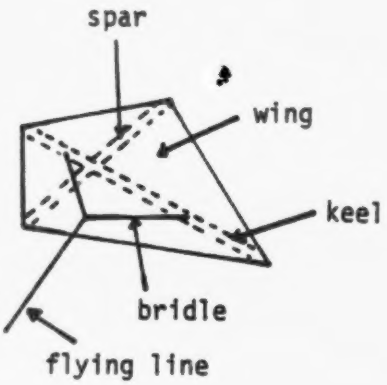
FLAT KITE

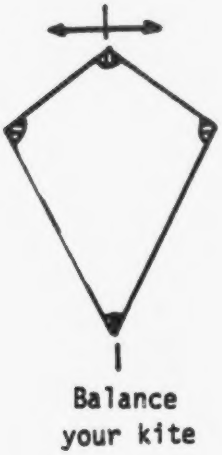
MATERIALS:
- string
- glue
- tape
- kite sticks
- paper or plastic

PROCEDURE:

1. A flat kite may be constructed by securing sticks in the manner shown and attach to paper or plastic.
2. Attach a string from the end of each spar to the end of each keel.
3. Cover the frame with glue or tape.
4. Attach the bridle and flying line.

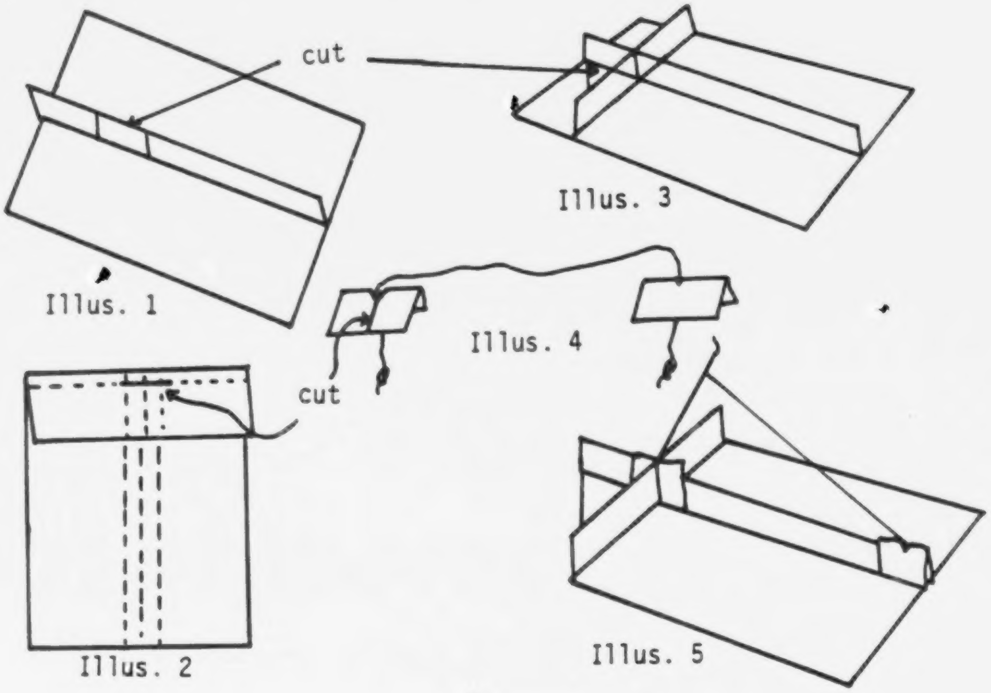
BASIC FLAT KITE





"GO FLY A KITE"

DUTCH KITE



Illus. 1

Illus. 2

Illus. 3

Illus. 4

Illus. 5

1. Fold and crease the paper the long way. Fold and crease again (2cm) from center fold. Open so the folded section forms a ridge up the kite. (Illustration 1)

2. Open paper flat. Fold and crease on a line (8cm) from the top (short way). Fold and crease (2cm) from this fold. Unfold this crease and cut on heavily marked lines at the top. (Illustration 2) Open paper flat, back side up.

3. Brush glue on the top and bottom sections of the long middle fold (between fold lines) but not on the cross-fold section where the H-shaped slit is located. Fold in center, spreading sides out flat, as in Illustration 1, thus gluing the spine of the kite. The cut flaps on the cross fold should slide over each other, one coming out on top of the kite, the other on the back.

4. Glue these flaps down (across the slit) on front and back of kite.

30

MORE WITH MODEL AIRPLANES

Objective: to make models and design test for distance and aerodynamics.

Materials: Balsa wood. Styrofoam trays. Diagrams of models. (See following 5 pages) Cardboard. Paper. Glue. Scissors. Notebook for recording data.

Procedure: Have students construct airplanes using the models shown. Encourage making different sizes, and using various materials.

Have students test airplanes under varying atmospheric conditions, including humidity, wind velocity, temperature, and other weather conditions.

Have students observe and record data concerning effect of conditions on each type of airplane assembled.

Have students draw conclusions on which type of airplane flies best under various types of conditions. Hypothesize what changes should be made on the planes to make them perform better under adverse conditions. Redesign and test. Record data.

Discuss such changes as adding flaps, moving wing forward and backward, changing the center of balance. What configuration helps make the plane fly straight and far? How can it be made to loop? To circle?

Extensions: Have children design their own airplane on paper. Discuss each child's design with the class. Get input from them. Decide which designs might be best for certain conditions. Ask the class to choose four or five of the designs they feel are the best to be made into models.

Separate the class into groups and have each group build an airplane from one of the model designs chosen. Test the design and keep records of its performance under various conditions. Have each group present its plane and discuss its good and poor points.

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Individual
Group

TIME:

2 or more
45 minute periods

TYPE OF ACTIVITY:

Student Investigation

CONCEPTS:

Aerodynamic design
variables

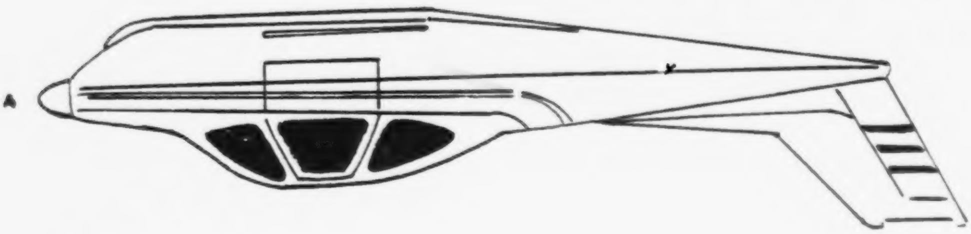
SKILLS:

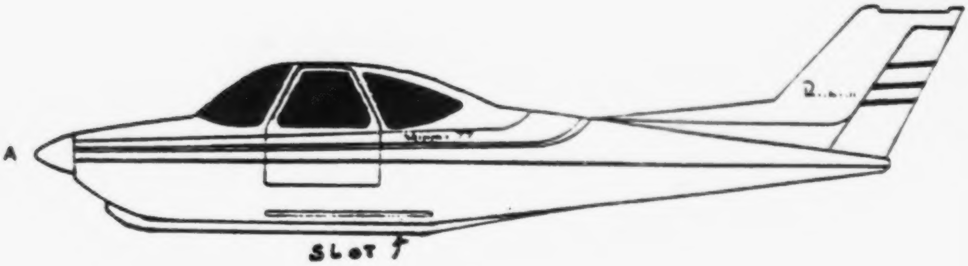
Observation
Collecting and
Recording data
Testing

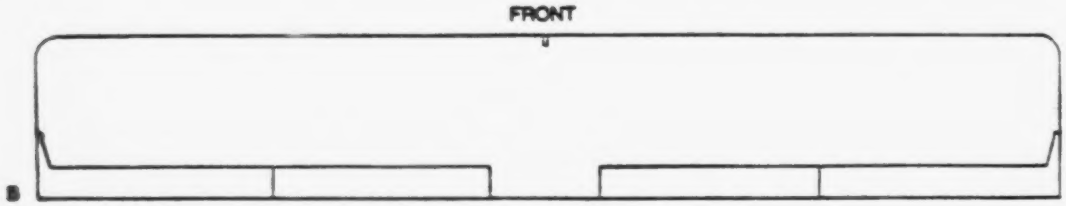
RESOURCES:

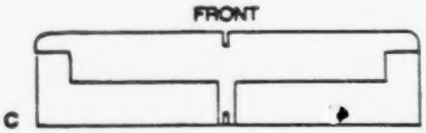
37, 39, 86

BEECHCRAFT--SKIPPER 77





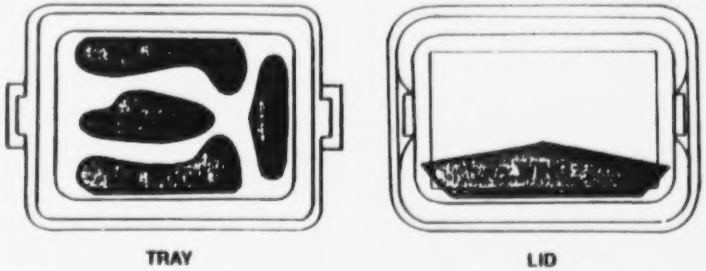


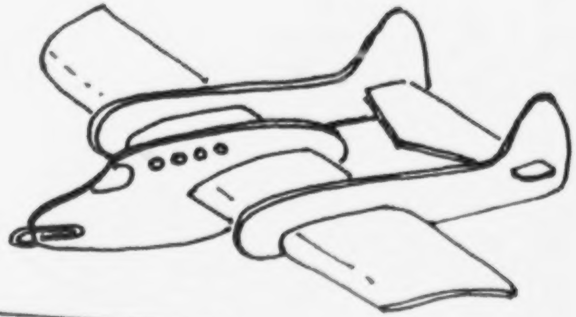


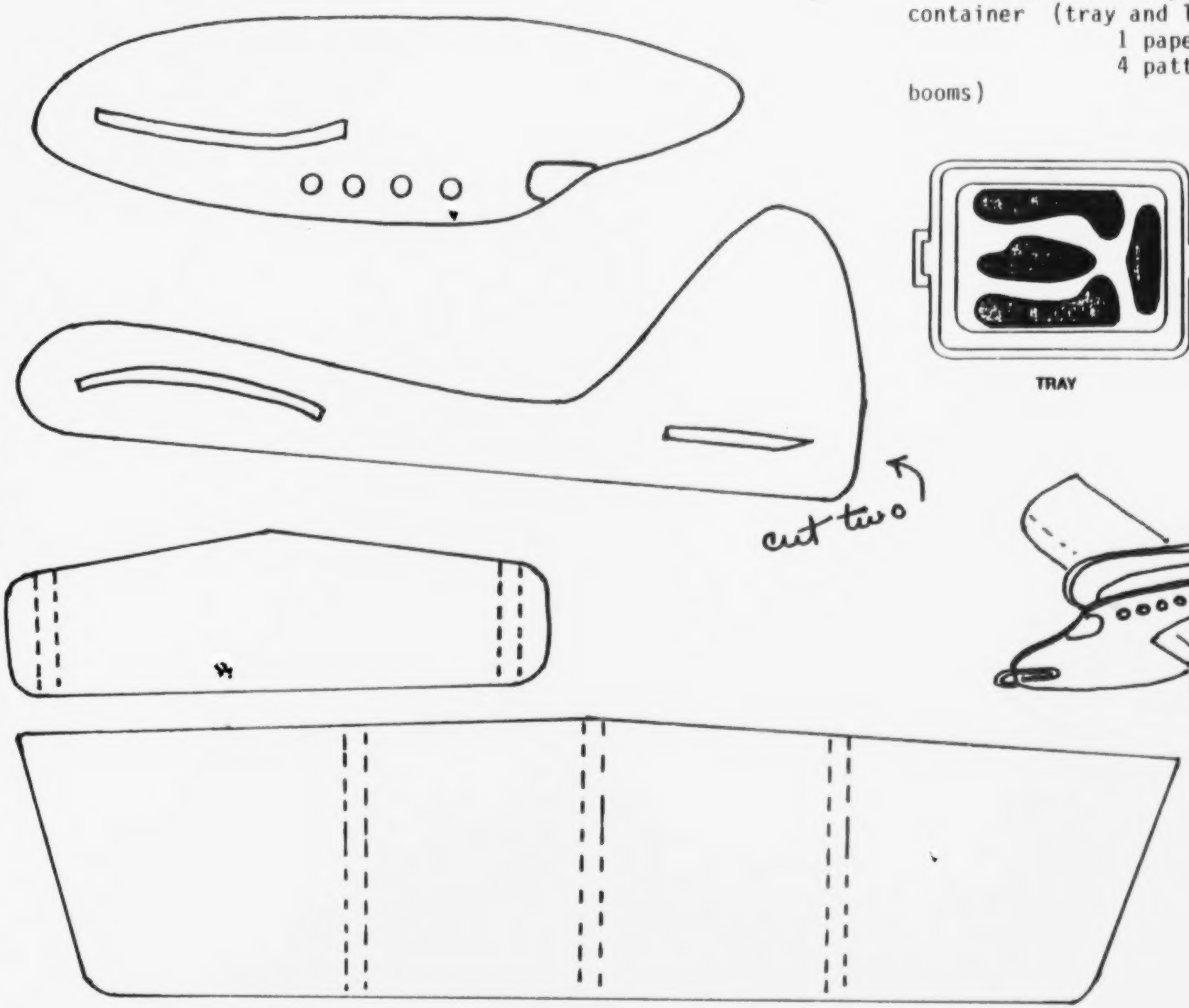
Cut out parts A (both), B and C.
Glue to light cardboard. Glue A's together.
Cut slot in Part A. (fuselage)
Insert Part B (wing) through slot in Part A.
Attach Part C (elevators and horizontal stabilizer assembly) to the top of the tail on Part A.
After assembly is completed, place a small drop of glue on each side of the fuselage by the wing, holding wing stationary. Place a drop of glue also on the underside of the horizontal stabilizer.

THE NO - GLUE SPECIAL.....

Materials: 1 styrofoam fast-food breakfast container (tray and lid)
1 paper clip (for ballast)
4 pattern pieces (cut 2 tail booms)



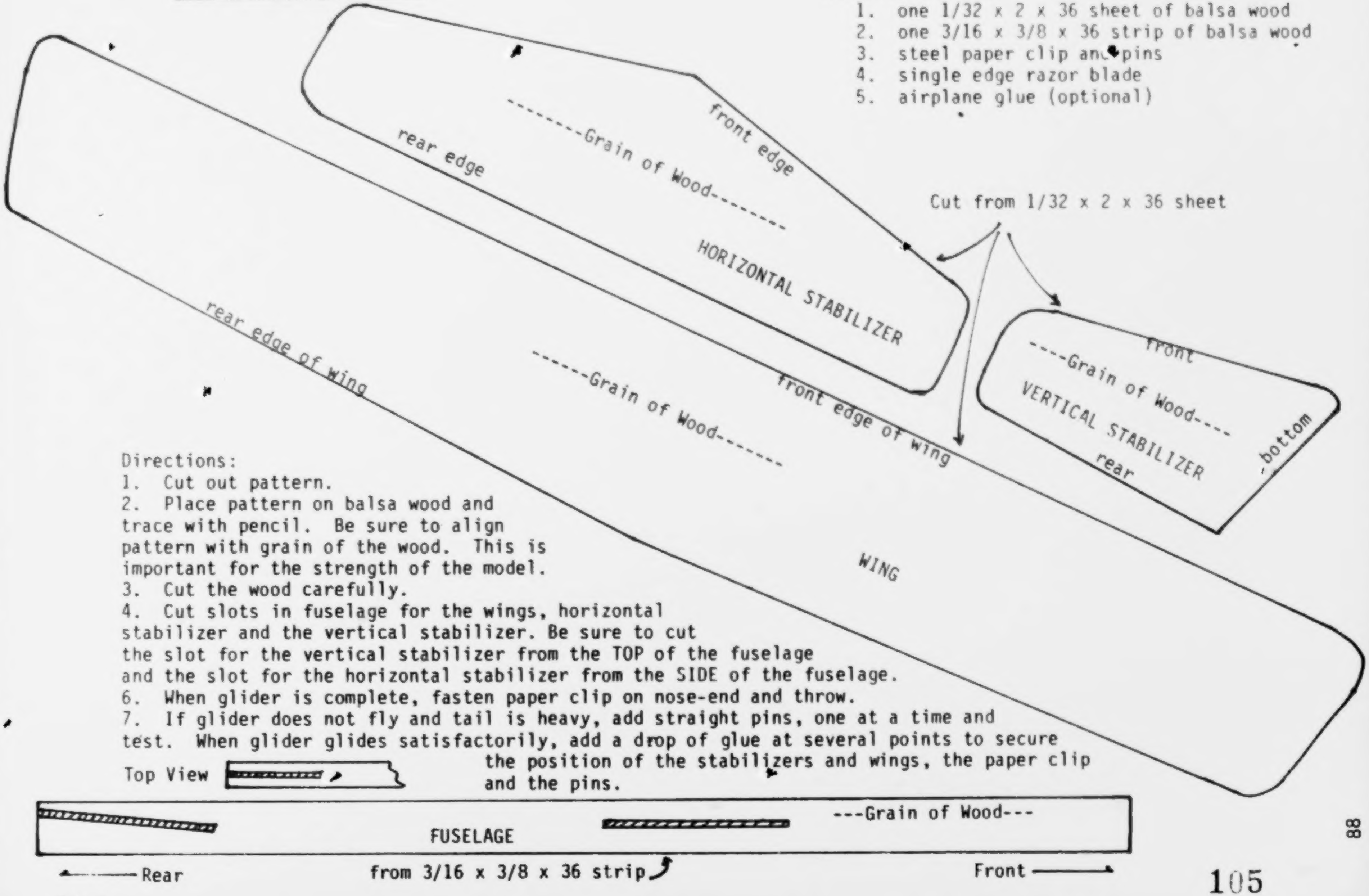




A BALSA AIRPLANE TO MAKE

Materials Needed:

1. one 1/32 x 2 x 36 sheet of balsa wood
2. one 3/16 x 3/8 x 36 strip of balsa wood
3. steel paper clip and pins
4. single edge razor blade
5. airplane glue (optional)



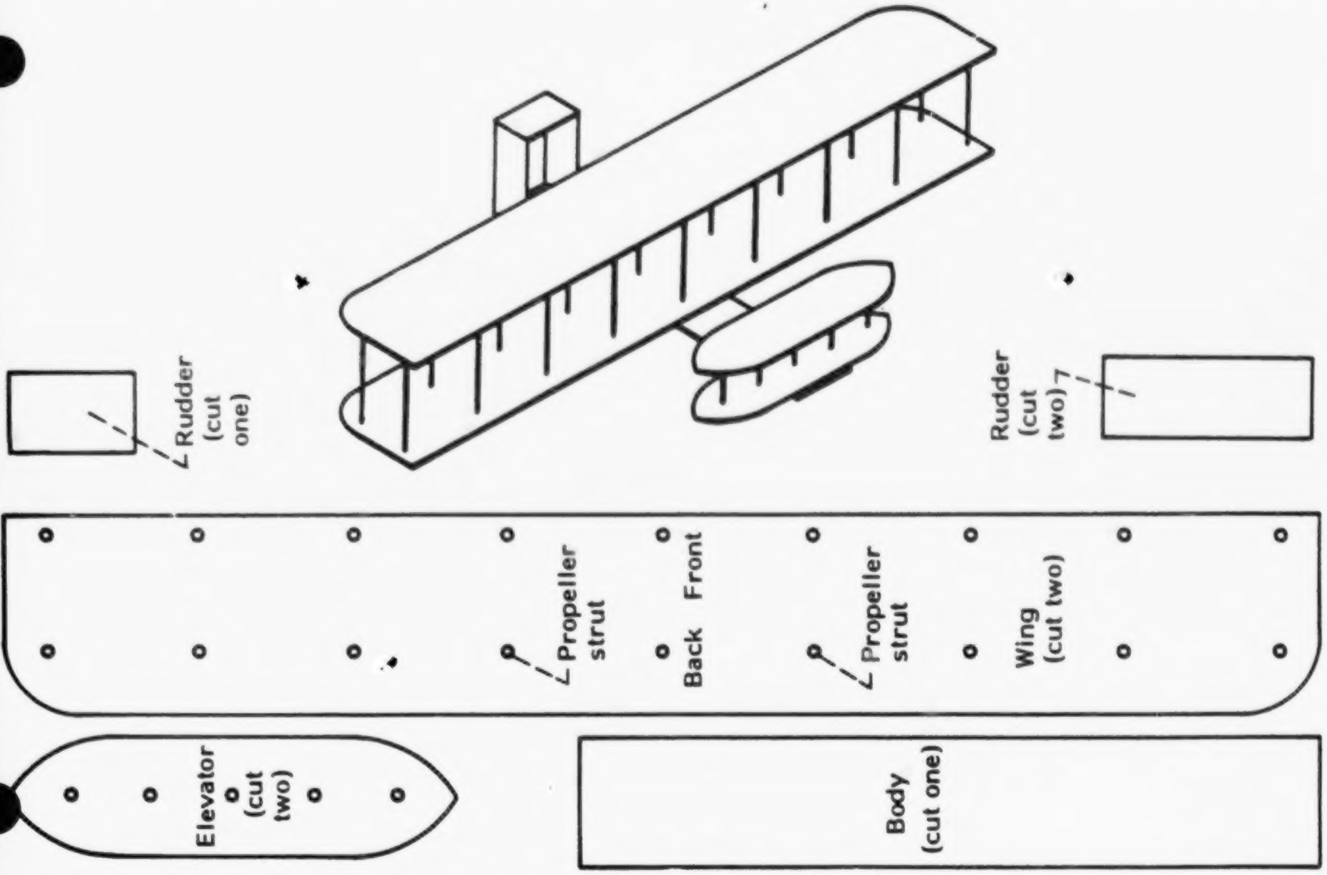
Directions:

1. Cut out pattern.
2. Place pattern on balsa wood and trace with pencil. Be sure to align pattern with grain of the wood. This is important for the strength of the model.
3. Cut the wood carefully.
4. Cut slots in fuselage for the wings, horizontal stabilizer and the vertical stabilizer. Be sure to cut the slot for the vertical stabilizer from the TOP of the fuselage and the slot for the horizontal stabilizer from the SIDE of the fuselage.
6. When glider is complete, fasten paper clip on nose-end and throw.
7. If glider does not fly and tail is heavy, add straight pins, one at a time and test. When glider glides satisfactorily, add a drop of glue at several points to secure the position of the stabilizers and wings, the paper clip and the pins.

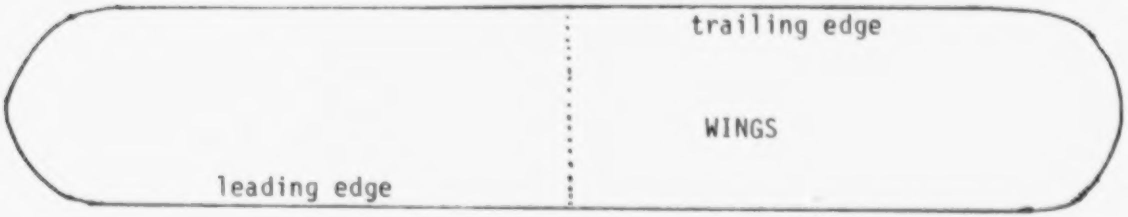
HOW TO BUILD A MODEL WRIGHT FLYER

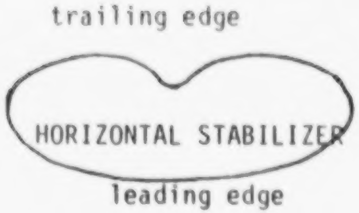
1 styrofoam meat tray or	1 dime
2 styrofoam egg carton tops	scissors
tape	carbon paper
wooden toothpicks	white glue

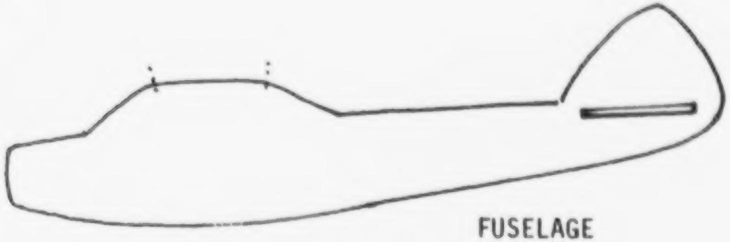
1. Trace pattern onto the styrofoam.
2. Cut out all parts. Shape the wings and elevators by cutting along the dotted lines.
3. Push toothpicks, lengthwise, through the center of each rudder. Glue each rudder upright at one end of the body - one to the right edge and the other to the left. Then glue on the rudder top.
4. Dip 18 toothpicks in glue and place the toothpicks upright on the dot marks. Dab glue on the toothpick tops and lay the second wing carefully on them, using the dots as a guide. Press together carefully. Cut a toothpick in half and glue one piece each to two middle toothpicks to look like propellors. Set aside to dry.
5. Assemble the elevator by dipping 5 half toothpick ends in glue. Place the toothpicks upright on the dots. Dab glue on the tops and place the second elevator on them. Press together carefully.
6. Glue the wings to the center of the body.
7. Glue the elevator to the other end of the body.
8. Tape a dime to the bottom of the Flyer between the wings and elevator.
9. Wait for the glue to dry. Now you are ready for take-off. Kneel down and fly your model - nice and low, just like the Wright Brothers flew their first flyer.



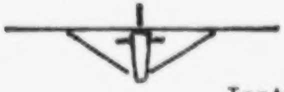
Take Me Out To The Airfield by Robert Quackenbush
Parents' Magazine Press, New York 1976






Cut this
slot out

FUSELAGE


Toothpick
wing support

Materials:
1. Styrofoam meat tray
2. Two toothpicks
3. White glue

Directions:
1. Carefully cut out the pattern.
2. Use a ball point pen to trace around the pattern on the styrofoam.
3. Cut out with single-edge razor blade or X-acto knife.
4. Sand all edges smooth. Sand the area where the wing attaches to the fuselage flat. Sand other fuselage edges round. Sand the leading edges of the wing and horizontal round; the trailing edge should be tapered sharp.
5. Glue the wing and horizontal stabilizer to the fuselage.

A STYROFOAM PIPER CUB

31

JET ENGINE THRUST

Objectives: to have students understand that jet planes and rockets get their thrust from air molecules; to have students identify the combustion chamber as one part of an engine involved with thrust.

Materials: (For A) Balloon. Empty bottle. Pan of Water. Stove or hot plate. (For B) Two or three wooden matches. Rubber band. Glass pill bottle. Cork. Vaseline. Magnifying glass.

Procedure: (A) Snap a balloon on an empty bottle and place the bottle in a pan of water on a hot stove. The heat will make the air molecules in the bottle move vigorously and bounce further apart.

As the air expands, it pushes against the bottle. What happens? Why?

(B) In a jet, the same thing happens in the combustion chamber. The burning fuel heats the compressed air and expands it greatly. The extra air has no place to go but out, so it rushes toward the nozzle. You can demonstrate this by using 2 or 3 wooden matches for fuel. With a rubber band, tie their heads together and drop them in a glass pill bottle. Cork the bottle, after first smearing vaseline where the cork and bottle touch (making an air tight seal).

Take the bottle outside in the sunlight. With a magnifying glass, focus the sun's ray on the match heads. The matches will catch fire very soon. What happens to the cork? Why? What does all this have to do with jet engine thrust?

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Small

TIME:

40 minutes

TYPE OF ACTIVITY:

Demonstration

TEACHING STRATEGY:

Expository

CONCEPTS:

Thrust
Combustion chamber

SKILLS:

Observation
Inference

RESOURCES:

56, 58, 80, 82, 188

32

WHAT DO YOU KNOW ABOUT THOSE FUNNY FORCES?

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Individual

TIME:
Open

TYPE OF ACTIVITY:
Student
Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Lift/Gravity
Drag/Thrust

SKILLS:
Experimentation
Recall

RESOURCES:
26, 28, 41-46,
48, 51, 52, 53

Objective: to help student identify the forces involved in flying a plane; or to provide an evaluation form for the understanding of the four forces: thrust, drag, lift, gravity.

Materials: Worksheet. Materials necessary for student to investigate or read in order to complete worksheet.

Procedure: Duplicate the activity sheet and distribute to each student.

1. Using the materials necessary, the students should do what ever activities are necessary to complete the activity sheet.

or

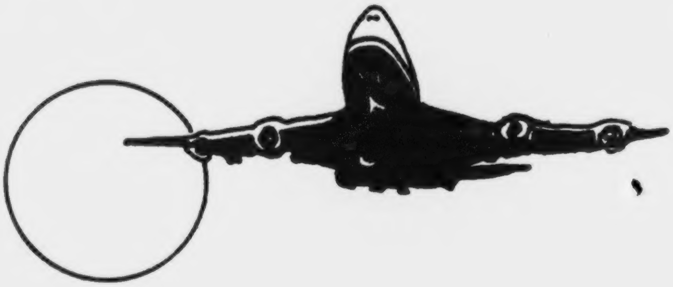
2. Use the worksheet as a test for recall after activities and reading have been done. Ask students to fill in the answers.

FORCES INVOLVED IN FLYING A PLANE

Write the word that fits in the blank, choosing from:

LIFT DRAG
THRUST GRAVITY

1. __________slows the forward movement of the plane.
2. __________gives an airplane its forward motion.
3. __________is produced by the angle of attack.
4. __________may be produced by jets or rockets.
5. __________is the resistance the air offers.
6. __________is a downward force.
7. __________is an upward force.
8. __________is caused by friction.
9. __________is a backward force.
10. __________is created by a power source.
11. __________produces the weight of the plane.
12. __________acts against gravity.
13. __________works against thrust.
14. __________may be produced by propellers.
15. __________is produced by the difference in air speed over the wing surfaces.
16. __________may be reduced by streamlining the plane's shape.



33

WILD AND CRAZY ROCKET MODELS

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Individual

TIME:
45-60 minutes

TYPE OF ACTIVITY:
Construction

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Rocket

SKILLS:
Motor coordination
Design
Creative thinking

RESOURCES:
181, 183, 194, 197

Objective: to help student develop motor and design skills; to enhance student's creative abilities; to demonstrate some basic rocket parts.

Materials: Cans. Plastic bottles. Cardboard. Paper. Wood. Wire. Paper clips. Paper cups. Tape. Glue. Whatever.

Procedure: This is as much for great fun and creative endeavor as anything else. Using whatever materials can be thought of and scrounged up, have students construct a model of a rocket. The model need not be exact nor even resemble an existing rocket. It need only have some resemblance to rockets. Make it out of whatever is available and as tall or as big or as tiny or short as the student's imagination. Paint it silver or white like conventional rockets or a rainbow of colors quite unlike anything NASA has seen.

A winners-only contest might follow. Make ribbons of merit for each one giving appropriate awards for what the student has constructed. "Most bizarre," "Most colorful," "Most Unlikely to Get Off the Ground," etc. Originality is the key here. And FUN.

NOTE:

On the next 3 pages are some very basic ideas to get started. Encourage kids to use the ideas only as a start to their own way-out approach to rocket design.

ANOTHER NOTE:

Words like "stabilizer," "staging," "fairing," "cone," etc. will come up. Discuss what these things are and encourage students to look at many pictures of rockets and to discover the names of some of the other parts they see on rockets. (Check out the NASA rockets in the Kindergarten section.)

PAPER ROCKETS

MATERIALS:

- Large plastic soda straws (the kind used in fast food restaurants). One per student.
- Sharpened thick pencils (same size as straws). One per student.
- Paper (8 x 10). Two sheets per student.
- Cellophane tape. One roll per two or three students.
- Scissors. One per student.

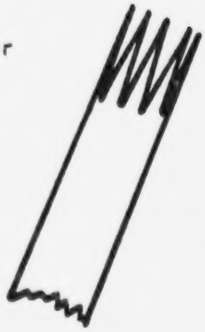


Fig. A

Procedure:

1. Cut a strip of paper about 8 inches long and 1 to 2 inches wide.
2. Roll the paper strip around the pencil and tape. Roll paper strip lengthwise around pencil. Paper tube should slide easily off the pencil but not be too loose.
3. Make several pointed cuts at one end of tube. See Fig. A.
4. Slide the sharpened end of the pencil toward the pointed cuts. Fold the points around the sharpened end of the pencil and tape to form the nose cone. See Fig. B.
5. Cut out two sets of fins. Use the pattern in Fig. C. Fold the fins on the dashed lines in the manner shown in Fig. C.
6. Using two pieces of tape, fix the fins to the opposite end of the tube from the nose cone. Insert the pencil for support in taping. See Figure D.

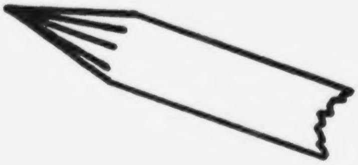


Fig. B

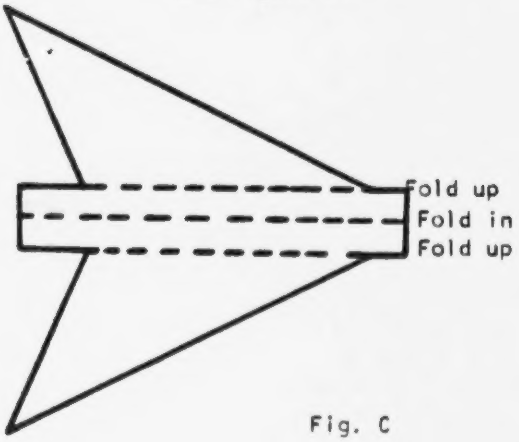


Fig. C

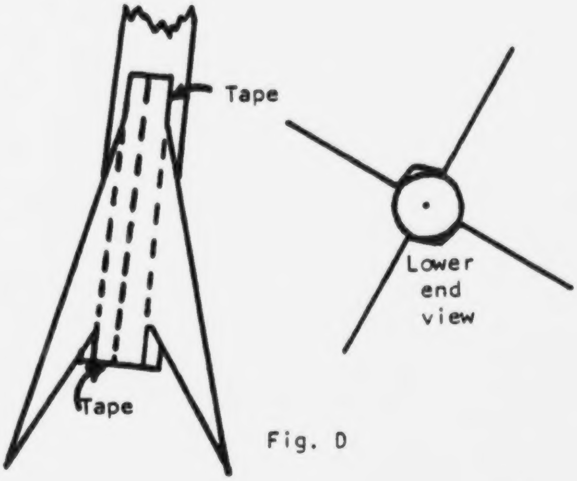


Fig. D

7. Place the rocket over the soda straw. See Fig. E.

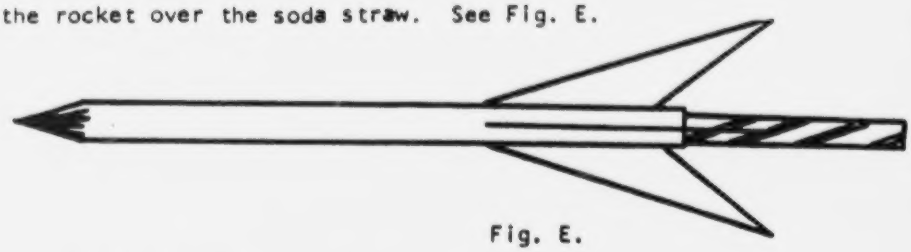


Fig. E.

8. Select a firing range to launch the rocket such as one side of the classroom or a hallway. A high ceiling room such as an auditorium or gymnasium is best.

9. Launch the rocket by blowing sharply on the straw. Be sure to aim rockets in the desired direction.

Discussion:

There are many variations in the design of paper rockets. Students should be encouraged to change the shape and size of fins and the length of the tube. Different forms of nose cones should be tried as well as different placements of the fins on the tube. Large fins can be used to turn the rocket into a glider. (See Fig. F.

To add extra interest to the activity, competitions can be organized. Try to find out which rocket can go the highest, the farthest, and land in a designated recovery zone, etc.

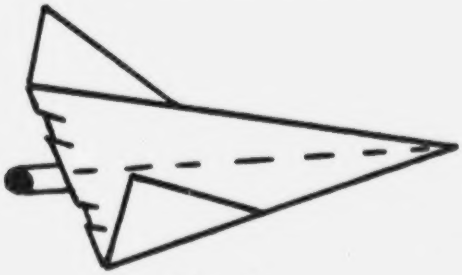
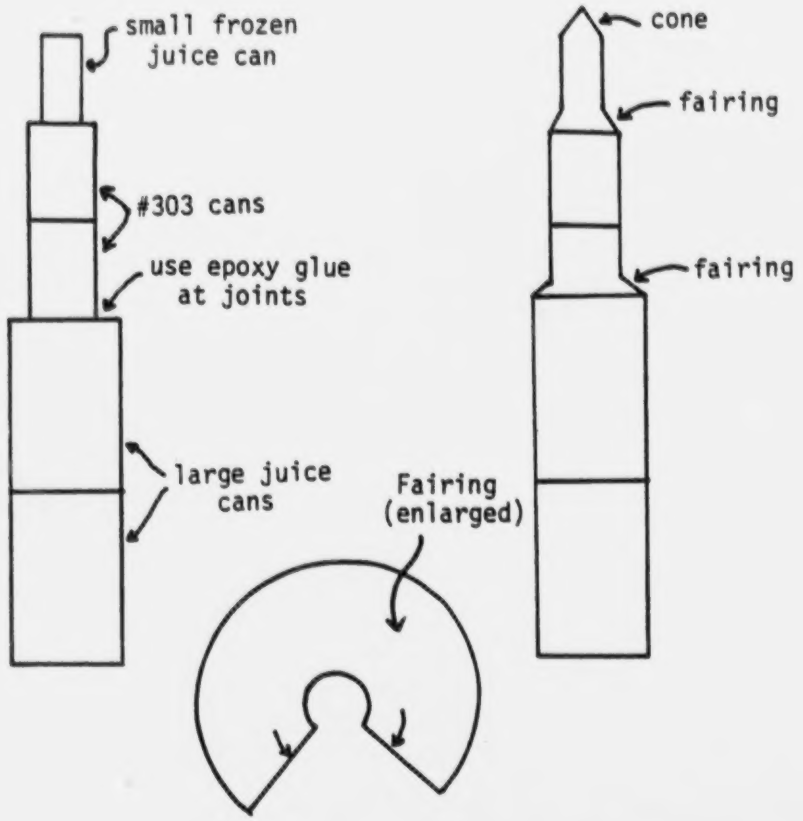


Fig. F.

SATURN V



Construct fairing from paper. Draw cut ends together to form cone. Experiment to find proper dimensions. Slip completed fairing over can assembly. Paint.

34

CONSTRUCTION OF AN ACTION-REACTION MODEL

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Large

TIME:
30 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Action-reaction
direction change

SKILLS:
Observation
Inference

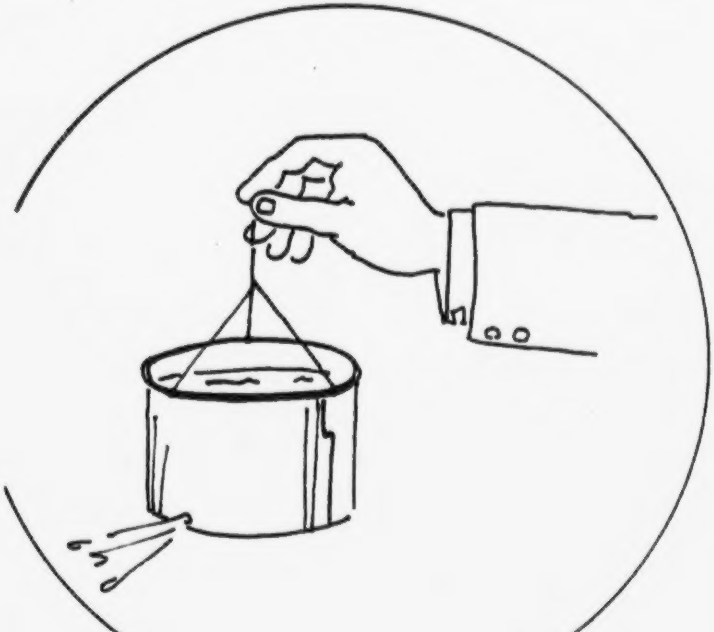
RESOURCES:
41 - 43, 298

Objective: to better understand how rockets and satellites change direction.

Materials: Water. Cord. Coffee can. Hammer. Small nails.

Procedure: Punch a small hole in side of coffee can near the bottom. Fill can with water and observe movement of can as water spurts from opening.

Discuss such questions as: How does Newton's Third Law apply to this investigation? How can the results of this investigation be related to "turning" a satellite by utilizing a liquid or gas (propellant)? How can one modify the apparatus to involve steam as the propellant? Where can the students look to find more information on how rockets and satellites change direction?



35

ROCKET PROPULSION I

Objective: to make a simple rocket engine to demonstrate rocket propulsion; to recognize Newton's Third Law of Motion.

Materials: Rubber bands. Balloons. Baking soda. Vinegar. Test tube. Two round pencils. Cork or Rubber stopper. Tissue paper.

Procedure: (A) Divide the class into groups of three and have one child in each group blow up one balloon. Have another child tie it tightly with the rubber band. Let each in the group try to make the balloon move and/or remain still. Discuss with the group what conditions are necessary for the movement of the balloon. (Source of energy; i.e, wind, push).

Have one child in each group untie the rubber band. Watch what happens and discuss what caused this action. Difference in air pressure and escaping jet of air? Discuss how this is like a rocket engine (unequal pressures cause motion of rocket) and how it is different (rockets need different kinds of fuel to generate new energy).

(B) Demonstrate this one. Loosely wrap two teaspoons of baking soda in a small piece of tissue paper and place in the bottom of the test tube. Put two round pencils on the table, three inches apart and parallel to one another. Quickly place a moistened stopper or cork into the test tube and place test tube on pencils. (This must be done very quickly.) What happens? Discuss why. What does mixing vinegar and baking soda produce? What is the action? The reaction? How is this related to the movement of a rocket engine?

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Experiment and
Demonstration

TEACHER STRATEGY:

Guided Discovery
Expository

CONCEPTS:

Action-reaction
Rocket propulsion

SKILLS:

Observation
Inference

RESOURCES:

188, 193, 194, 298

36

ROCKET PROPULSION II

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Small

TIME:
30 minutes

TYPE OF ACTIVITY:
Experiment

TEACHING STRATEGY:
Guided Discovery

CONCEPT:
Action-reaction
Staging

SKILLS:
Observation
Inference

RESOURCES:
40, 188, 298

Objective: to understand the value of staging.

Materials: Two 6" or 8" balloons. One 3 or 4 oz. Dixie cup. One Plastic straw cut in 4 equal lengths. 50-60 feet of heavy thread or fish line. 4 pieces of masking tape 4" long.

Procedure: 1. Cut the bottom out of the Dixie cup.

2. Extend nozzle of balloon B through the now hollow cup and stretching the balloon, inflate it. Hold balloon B between thumb and finger on B side of Cup C and pull the nozzle of balloon B against the side of cup C. Refer to illustration.

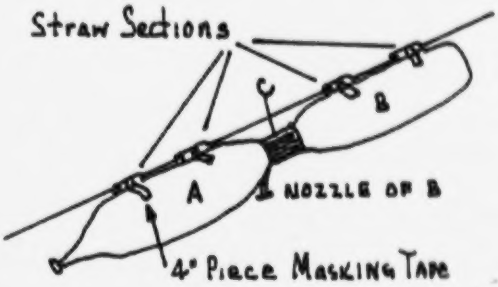
3. Insert balloon A into the cup and inflate. Release balloon B. A now holds B in position.

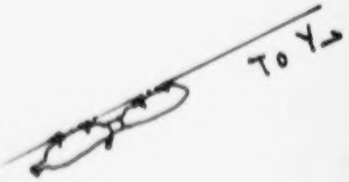
4. Holding nozzle of A closed, attach the assembly to the 4 spaced pieces of plastic straw which should have been placed on the 60 foot string by another group. Refer to illustration.

5. If a stairway is available or if you are in a gym, have the Y station higher than the X.

6. Release Balloon A. What happens? How does the experiment relate to rocket propulsion and staging? What is the value of staging? Discuss such things as the reduction of weight with staging. Or the construction of smaller parts rather than large cumbersome ones. Or the reduction of failure of any one component because of heat or vibration. Or the ability to vary thrust, etc.

Discuss the horsepower of rockets. Saturn V has 150 million horsepower. How many average size cars would be required to develop the horsepower of Saturn V?





37

BOOM!

Objective: to enable students to understand the concept of sonic boom or shock waves by producing a miniature shock wave.

Materials: Empty can, open at both ends. (A two pound coffee can is good.) Plastic lid which fits over the end of the can. (Light cardboard cut in circle and attached with masking tape works, too.) Rubber bands or string. Large balloon. Matches or small birthday cake candle.

Teacher Background Information: When a spacecraft slashes back into the earth's atmosphere, the force and speed of its re-entry creates shock waves. The effect is an immediate build-up of frictional heat of such intensity that the capsule might disintegrate were it not for the design of the spacecraft whose forward area is shaped specifically to deflect the shock waves. Thus deflected, the shock waves--searing hot in themselves--form a protective cushion between the vehicle and the even higher temperatures of the surrounding atmosphere.

Another kind of shock wave is created when the speed of trans-sonic aircraft and rockets approaches the speed of sound (760 miles per hour at sea level). A vehicle traveling at this speed piles up molecules of air in front of it until they form a wall of high pressure. By increasing its speed, the vehicle can penetrate this wall but it will be buffeted as if in a violent storm.

Aircraft and rockets which travel faster than the speed of sound drag a compressed air barrier behind them similar to the wake that follows a speed boat. As the wake of the boat slaps against other objects in the water and against the shore, just so does the compressed air barrier trailing a supersonic craft hit the ground with the familiar boom often heard as such a vehicle travels through the skies.

Procedure: To experience the effect of a compressed air barrier, cut a small slot (like in a piggy bank) in the center of the plastic lid. Cut the large balloon far enough back of the nozzle to allow the open end of the balloon to fit over one end of the can. Fasten the open end of the balloon over the can by working rubber bands around it or tieing it with string.

Fit the plastic lid over the other end of the can. Grasp the balloon in the center and pull it back while holding the can firmly with the other hand. Release the balloon and listen. What happens? Why? Light a small candle and aim the slot in the can lid at the candle flame from about 18" away. Pull the balloon back and release it. What happens to the candle flame? Why?

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Small or Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository

CONCEPTS:
Sonic boom
Shock wave

SKILLS:
Observation
Inference

RESOURCES:
56, 68, 200, 204

BOOM! (continued)

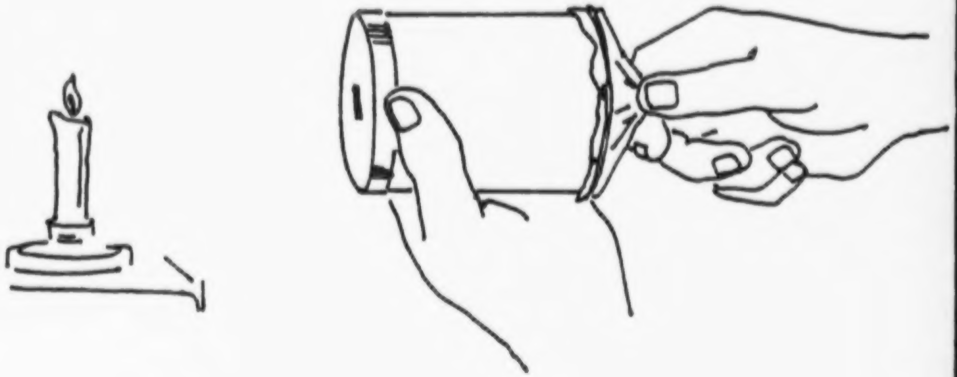
Extensions: 1. Experiment with effect on the candle flame by releasing the air in the can slowly, then at increasing rates.

2. Study the effects of various sizes and shapes of openings in the plastic lid.

3. Study the effects of various shapes and positions of baffles placed in front of the opening in the can lid. The baffles can be made of heavy paper or light weight cardboard.

4. Light a number of the small candles and place them in a row at right angles to the can lid and produce a boom. Does the boom spread after it leaves the shock wave generator?

5. Search for answers to such question as: How hot does it get during re-entry? What sort of insulating materials can be used? What sorts of problems can a sonic boom cause?



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WEATHER PICTURES

Objective: to establish the relationship between sky conditions and basic kinds of weather.

Materials: Construction paper. Drawing paper. Crayons. Paint. Chalk.

Teacher Background Information: This lesson is designed to have students observe and record data about sky conditions in order to see correlations between those conditions and certain weather patterns. It is important to give children a chance to record and express data in several ways. Some students may wish to make graphs or keep charts with written data. Others may prefer to do pictures or other art representations. No one way is the best way if the children understand the meaning of their graphics. This understanding is maximized when they choose a representation they feel comfortable with.

Procedure: 1. Begin with a discussion of sky conditions on a very basic level.

Examples:
- a. What does the sky look like just before a big storm?
- b. What does the sky look like when it is full of lightning?
- c. What does the sky look like after rain?

2. After the discussion, lead children into creating a picture of a sky for various weather conditions, such as: "Lightning and Rain," "The Storm Gathers Above Us," or "Cold and Snow in Winter."

3. Have the students make graphs of the sky conditions on one side of a piece of paper and the resulting weather on another side. Have them draw conclusions and make predictions after several weeks of observations about daily weather based on their observations.

Try again after several months of observation. What happened to the accuracy of the predictions?

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Discussion
Creativity Activity

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Weather
Variables

SKILLS:

Observation
Drawing
Conclusions

RESOURCES:

2, 6, 7 - 13,
14, 22

39

SIMPLE WIND VANE

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Large or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Construction

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Wind
Constructing
Testing equipment

SKILLS:

Observation
Inference
Construction

RESOURCES:

6, 20, 40

Objective: to construct and utilize a student made device to detect the source of wind direction.

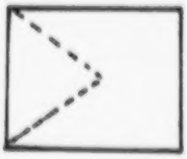
Materials: For each student-4"x4" square of cardboard. Clay. Paper straw. Pencil with Eraser. Straight pin. Construction paper 2½" X 2". Scissors. Glue. Model airplane. An electric fan for the class.

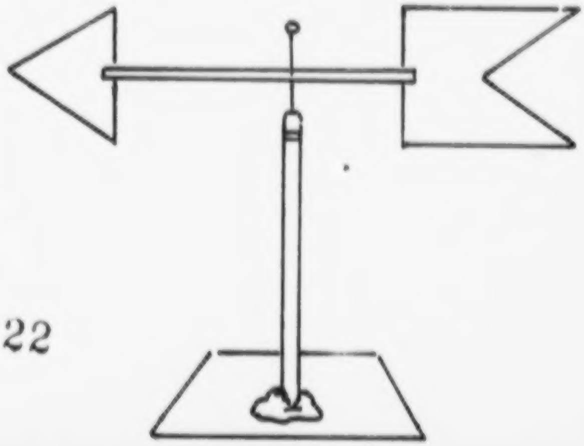
Procedure: Discuss the importance of knowing wind direction when flying a plane. Ask why it's important to know direction for take offs and landings. Suggest that they make their own individual device to determine wind direction with the materials you have given them. Give them some time to discuss how it might be done with what they have in front of them and to experiment a bit. For those who need more direction, tell them to:

1. Cut a pointer and tail out of the construction paper.
2. Flatten ends of the straw. Glue pointer and tail to these ends. Let dry.
3. Stand pencil point in a mound of clay which has been centered on the cardboard.
4. Determine the center of gravity of the straw. Push pin through it and into the eraser of the pencil.

Let students observe the movement of the arrow with an electric fan as the wind source. Discuss applications of the wind vane in flying model airplanes. Use the wind vane to fly planes outside.

Extension: Use the wind vanes in weather-reporting activities. Use to teach wind directions.





40

SOCK IT TO ME

Objective: to construct and observe the operation of one kind of wind direction indicator (windsock)

Materials: Heavy cloth, about 36" x 24". Four lengths of heavy wire, about 10" each. Wire coat hanger. Pole, about 36" long. Large nail. Wooden spool. Needle. Heavy thread.

Procedure: 1. Form the hanger into a loop about nine inches in diameter.

2. Attach the four wires to this circular hoop at four equi-distant points on its circumference.

3. Cut the cloth into a sleeve (see illustration).

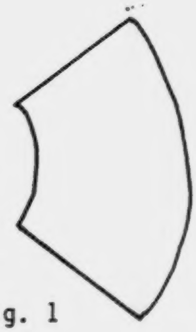


Fig. 1

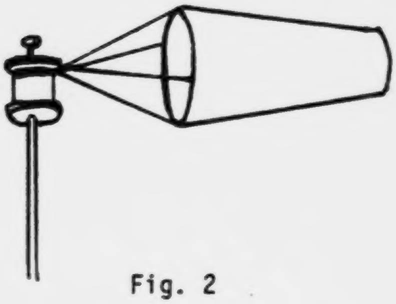


Fig. 2

4. Sew the sides together making a cone and sew the larger ends of the cone to the loop and bind the exposed ends of the wires to the spool.

5. Place the nail through the spool, so that the spool may pivot freely on the nail. Hammer the nail into the end of the long pole.

6. Place the pole outdoors and nail it to a tall post or to a rooftop, away from obstructions, so that the sock may swing freely with the wind.

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Small

TIME:

40 minutes

TYPE OF ACTIVITY:

Construction

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Construction of a model

SKILLS:

Observation
Inference
Collecting/Recording Data

RESOURCES:

6, 40, 298

SOCK IT TO ME (continued)

7. Discuss the notion that pilots need to take off and land into the wind. Figure out why. Explain that pilots remember which way the wind is coming by putting themselves in the sock and flying out of the big end. (Mentally, of course!)

8. Over a period of time, have students check each day to find the direction of the wind and chart the results.

9. Discuss not only wind direction but wind speed. Can students see a difference in wind speed with the sock? How? By observing what other objects? How accurately can wind speed be noted? Make a simple anemometer or purchase one and record wind speed.

41

MEASURING THE WIND

Objectives: to use an anemometer to record wind speed in non-standard measurement; to relate wind speed to flying conditions.

Materials: Plastic funnel. Sharpened pencil a bit taller than the funnel. 2 Cardboard strips with a hole punched in the center of each. Masking tape. Scissors. 4 open boxes made from graph paper. Marker. Stopwatch or clock with second hand.

Procedure: (Teacher) Make an anemometer using the directions on following page or have students make them.

Have students create a breeze by blowing into the boxes. Count the number of times the colored box passes a marked point. (Do it per 15-second time periods and then convert to kilometers. A count of 30 in 15 seconds (2 counts per second) would be approximately the same as a wind speed of 6 to 7 kilometers per hour.) Have students blow softly and count and then blow more strongly and measure. What happens? Use a fan or hair dryer and measure. Test it outside in various winds. Talk about the differences and fly paper airplanes to test when the wind speed causes problems.

Headwinds. Have students throw their paper airplanes into the wind (outside or toward a screened fan). Have them throw their airplanes without any wind. Discuss the differences in the speed of the planes. Ask if there is a 20 mile an hour headwind and a plane is flying directly into it at 100 miles an hour, how fast is the plane actually flying over the ground? Crosswinds. Experiment with throwing the paper airplanes to a specific target with a crosswind as a problem. What do they have to do to get the plane to go where they want it to go? Investigate with different wind speeds.

SUBJECT:
Science

GRADE:
Third

GROUP SIZE:
Small or Large

TIME:
45 minutes

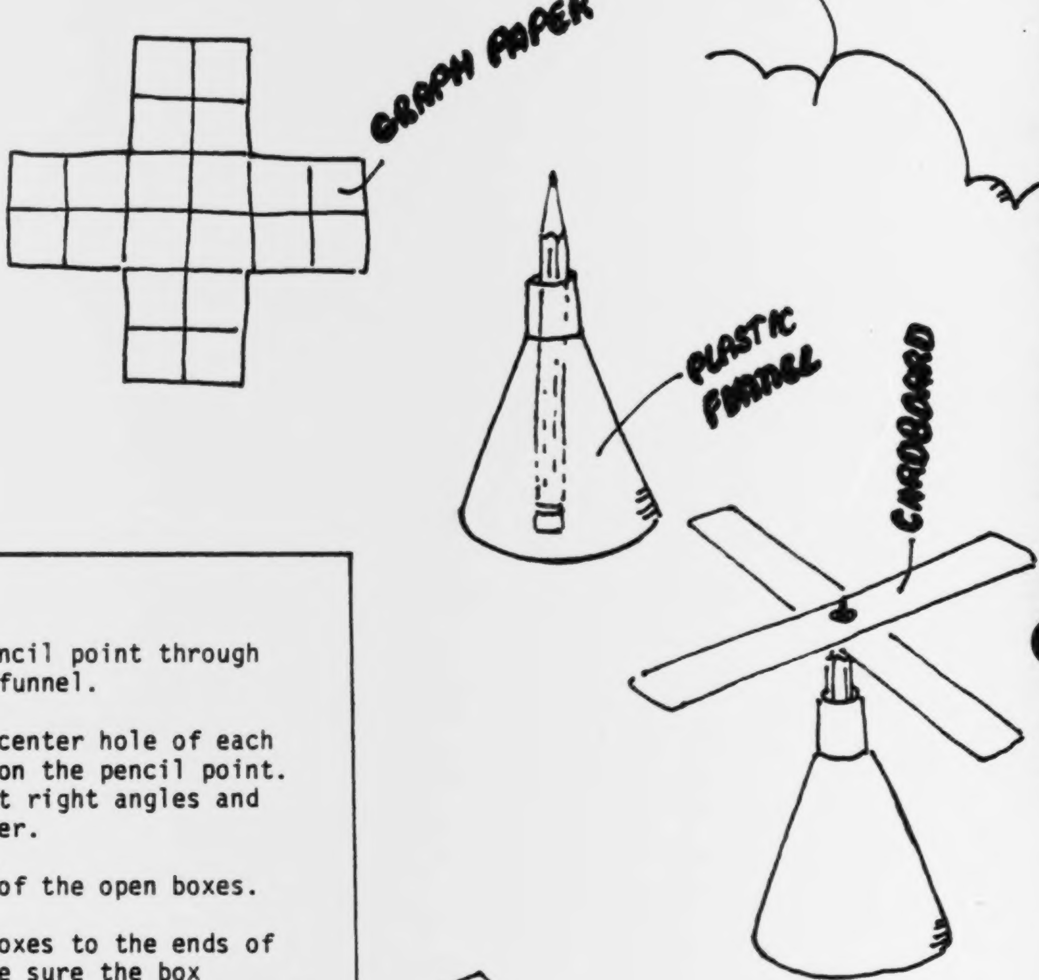
TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Wind Speed

SKILLS:
Measurement
Data Collection
Inference

RESOURCES:
6, 40



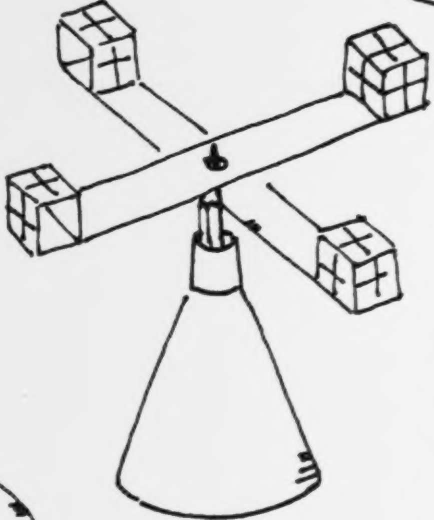
WHAT TO DO....

1. Put the pencil point through the hole in the funnel.

2. Place the center hole of each cardboard strip on the pencil point. Put the strips at right angles and tape them together.

3. Color one of the open boxes.

4. Tape the boxes to the ends of the strips. Make sure the box openings are facing the same direction - either clockwise or counterclockwise.



MEASURING THE WIND...

42

TEMPERATURE TAKING TIME

Objective: to provide an understanding of temperature and some of the ways temperature may affect flying.

Materials: Thermometers. Daily newspaper forecast. Chart for recording week's temperature readings.

Procedure: Attach a thermometer outside the window. Make a bulletin board with pictures of different temperature conditions. As students do this activity, have them add their own pictures or drawings to the board.

Have students check the temperature at opening and closing of school and record on the chart. Provide the daily forecast each day and compare their reading with forecast. Is there a difference? Why might there be?

Have students place other thermometers in various sunny to shady parts of the school yard and check the differences in temperature. Discuss variables when collecting data. Ask how two students might come up with different air temperatures depending on where they placed their thermometers. Make some predictions about the higher or lower temperatures of various places around the school based on location and time of reading.

Discuss flying and temperature. What temperature conditions might affect flying? How might very hot weather affect the flight characteristics of a plane? What are the dangers in very cold weather when flying? What kind of mechanisms are available to large commerical planes that make them safe to fly in very cold weather that are not generally available to most small plane pilots? Where is it coldest - close to the ground or high in the air? How does the temperature of the air differ over water as opposed to land? Devise methods to test for some answers to these questions WITH the students.

Extension: While on temperature you might get into the connection between temperature and wind. Ask why temperature is important to the idea of wind. (When wind blows, it's usually because cooler air is pushing aside warmer air) Ask why there is usually a heavier wind situation in winter than in summer. Find a map of the hemisphere showing the prevailing wind pattern for our locale. Discuss windchill.

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Individual

TIME:

45 minutes first day/10-15 minutes for next 4 days

TYPE OF ACTIVITY:

Student
Investigation
Discussion

TEACHING STRATEGY:

Guided Discussion

CONCEPTS:

Temperature
Variables
Data Collection

SKILLS:

Observing
Recording Data
Inference

RESOURCES:

2, 6, 21

43

WEATHERPERSON FOR A DAY

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Individual
Small group

TIME:

45 minutes

TYPE OF ACTIVITY:

Student
Exploration

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Air movement
Highs and lows

SKILLS:

Observation
Drawing conclusions
Interpretting data
Making predictions

RESOURCES:

3, 9, 21, 22

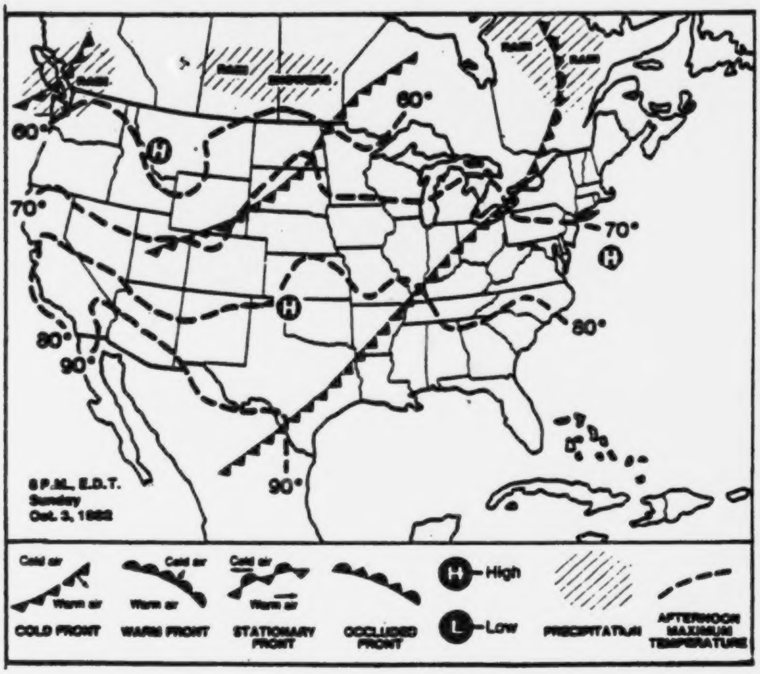
Objective: to become familiar with the procedures used in predicting weather.

Materials: Copies of weather maps from newspaper or from the local weather service.

Procedure: Distribute copies of the weather maps. Discuss the charts and the symbols used. Discuss air movement from high to low pressure areas. Discuss the circular pattern. Talk about certain clouds as forerunners of particular weather conditions. Ask how predicting weather fits into a discussion of flight.

Have each student record the present weather using the station model for reference. Discuss what the weather will be like for the next 24-hour period given the available information. What will the weather be like where student lives? Would they fly?

NOTE: Charts and maps can be obtained from:
US Department of Commerce
Environmental Science Services Administration
Environmental Data Service
Silver Springs, MD 20910



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44

WEATHER CENTER

Objective: to give students opportunity to record data of various elements of the weather and to look for patterns in that data as well as to do some simple weather predicting.

Materials: Weather vane. Anomometer. Windsock. Barometer. Rain Gauge. Thermometer. Charts for recording elements. (Following two pages for teacher.)

Procedure: Set aside a portion of the room near a window for the Center. Attach the various instruments where appropriate and provide a bulletin board with the various charts displayed. Provide library books on weather for the Center and drawing paper for drawing representations of observations.

Keep accurate records each day by rotating the responsibility for measurement between students. Have students note the kind of moisture that prevails. Using the two following pages on "Clouds" and "Rules for Amateur Weather Prediction" as a start, talk with students about what they observe and what patterns they are able to see. Make some predictions about rain or temperature or high winds, etc., and see if predictions improve over period of time.

Discuss the connection between flying and the weather. Ask students how thunderstorms affect the small plane pilot. The commercial pilot? What does the pilot need to know about wind? or Clouds? Why is prediction important to the pilot? Why might it be important for a pilot to know how fast a thunderstorm is moving?

Extension: See if you can arrange for a pilot and a weatherperson to talk with the students, on the same day if possible.

SUBJECT:

Science

GRADE:

Third

GROUP SIZE:

Individual

TIME:

5 - 10 minutes per day

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discussion

CONCEPTS:

Weather
Variables
Data Collection

SKILLS:

Observing
Recording data
Predicting

RESOURCES:

4, 7, 20, 22

RULES FOR AMATEUR WEATHER PREDICTION.....

1. A falling barometer indicates an approaching "low" with a storm.
2. A rising barometer indicates the passing of the 'low" and the approach of a "high" - fair weather.
3. The passing of the "low" in summer, will be followed by warmer weather.
4. Cirrus and cirrostratus clouds, coming from the west with a grey sky, indicate the approach of a "low," with accompanying storm.
5. A bright blue sky with cirrus wisps and with wind in the west or northwest will be followed by fair weather for twenty-four to forty-eight hours or longer.
6. Conditions of strong convection currents that produce thunderstorms may also be expected to produce hail.
7. If the lightning of a thunderstorm appears to the north, east, or south, the thunderstorm will not reach the observer.
8. If the lightning of a thunderstorm appears to the northwest, west, or southwest, the thunderstorm will come nearer the observer and perhaps pass overhead.
9. One can calculate the distance of the lightning flash, that produces the thunder, by counting the seconds between flash and the accompanying thunder and allowing five seconds for each mile the sound travels.
10. The thunderstorm travels on the average about 25 miles per hour; if the cloud is in the southwest, west, or northwest, one may estimate when the storm will strike by calculating the distance away.
11. A wind vane points in a general direction to a high pressure area.
12. Rainy weather or snow may come when the wind shifts in a counter-clockwise direction.
13. Winds from a "low" will blow in a direction opposite to that of the "low's" movement because of the counter-clockwise swirling of the winds in a "low."

CLOUDS........

NAME	DESCRIPTION	SIGNIFICANCE
CUMULUS	Fluffy, billowy floating 2,000 - 4,000 feet elevation	A fair weather cloud.
ALTOCUMULUS	Like wool packs or big lumps of cotton. 10,000 - 16,000 elevation	Fair weather clouds.
CIRRUS	Thin, wispy, feathery and silky. 18,000 - 52,000 ft.	If clouds look feathery good weather often follows.
STRATUS	A heavy grey blanket over whole sky. Really a heavy fog which has risen. Mostly below 5,000 ft.	"Low ceiling." Rain not necessary but probable.
CIRROSTRATUS	A thin, whitish blanket through which the sun shines producing halos. Around 25,000 ft.	Usually with forecasts of rain or snow within 24 hrs.
ALTOSTRATUS	Smooth, gray blanket that blots out sun. Around 25,000 ft.	If clouds start thin and grow thicker, rain or snow often follows.
STRATOCUMULUS	A high cloud, flat beneath and rounded at the top. Soft grey with darker parts. 2,000 - 6,000	May produce light rains.
CUMULONIMBUS	Bases may almost touch the ground. Anvil shaped top. 2,000 - 4,000	Storm clouds; lightning, rain, hail. Also produces tornadoes.

"SOMEDAY I'LL WISH UPON A STAR"

"I KNOW OF A SUN THE SIZE OF THE EARTH — AND MADE OF DIAMOND."

CARL SAGAN,
SPACE SCIENTIST AND ASTRONOMER

45. PLANETS MADE TO SCALE
46. NIGHT AND DAY
47. PLANETS IN ORBIT I
48. PLANETS IN ORBIT II
49. SUN SIZE
50. HOT, HOTTER, HOTTEST
51. ASTRONOMICAL ANSWERS
52. GYROSCOPES AND GUIDANCE SYSTEMS
53. USING REFERENCE OBJECTS
54. POLAR COORDINATES
55. POLAR COORDINATES AND FLYING IN MICHIGAN
56. COMPASS ROSE
57. PROBING THE EARTH
58. RECTANGULAR COORDINATES
59. PICTURES FROM SPACE
60. FORMING AN IMAGE WITH PIXELS
61. COLORING YOUR OWN "LANDSAT"

45

PLANETS MADE TO SCALE

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Large

TIME:
60 Minutes

TYPE OF ACTIVITY:
Modeling

TEACHING STRATEGY:
Expository

CONCEPTS:
Solar System
Relative size
Relative position

SKILLS:
Making models
Measuring
Scaling

RESOURCES:
133, 156, 162,
168, 169, 176

Objectives: to help students understand the relative sizes of the planets; to construct a model of the solar system.

Materials: Colored paper or balls of various sizes. Ruler. Labels. Markers. Tape measure. Paper. Glue. Light wire.

Procedure: Using the scale measurements below, find common items that measure approximately the same size (ping pong balls, tennis balls, beach balls, etc.) OR use circles of paper cut to scale size instead of the balls.

Planets	Diameter in Miles	Scale Measurement
Mercury	3,000	1 inch
Venus	7,600	2 1/2 inches
Earth	7,900	2 3/4 inches
Mars	4,200	1 1/2 inches
Jupiter	87,000	2 feet 5 inches
Saturn	71,500	2 feet
Uranus	29,500	10 inches
Neptune	27,000	9 inches
Pluto	3,600	1 1/4 inches

Label each ball with the name of a planet. Put in order in a display. (The paper circles work really well on the board).

Have the students research in order to find out the distances between the planets and get them to calculate a scale for those distances. When an accurate calculation has been made (and it may surprise them to find how difficult this is to achieve due to the vast distances between the planets) have the class make a set of planets out of paper mache and arrange in a wonderful display. (in the hall, outdoors, in the gymnasium.

Extension: Language arts fun. Have students make a sentence out of the first letter of each of the planets in the order they orbit away from the sun. For example: My Very Elderly Mother Jumped Sideways Upsetting Nora's Plant. (or... Upset by Nancy's Panther, or Upsetting Nobody in Particular)

PLANETS MADE TO SCALE (continued)

NOTE: At the present time that order is different. Neptune and Pluto are reversed and will be for another 17 years or so when they revert back to their more typical order. Have the students check that out and write a sentence for this phenomena.

Extensions: Define the terms: (1) solar system (2) galaxy (3) universe (4) star (5) planet

Form nine groups of students and assign each group a planet. Each group should learn:

a. The color of their planet.
b. Any special features.
c. How many moons it has.

Find books with pictures and descriptions of the nine planets and give each of the nine groups styrofoam balls as follows:

12 inch for the Sun . . . yellow with black or brown dots.
1 inch for Mercury . . . reddish
2 inch for Venus . . . blue with cotton for clouds
2 inch for Earth . . . blue with cotton clouds and brown continents
6 inch for Jupiter . . . banded with red spot
6 inch for Saturn . . . orange with rings cut from paper
4 inch for Uranus . . . bluish green
2 inch for Mars . . . reddish brown with dark markings
1 inch for Pluto . . .?

Have students paint them and hang them in order in the classroom from strings. Add pins for moons.

46

NIGHT AND DAY

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Small or Large

TIME:
30 minutes

TYPE OF ACTIVITY:
Student Investigation.

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Night and Day
Rotation

SKILLS:
Modeling
Drawing Conclusions

RESOURCES
143, 166, 298

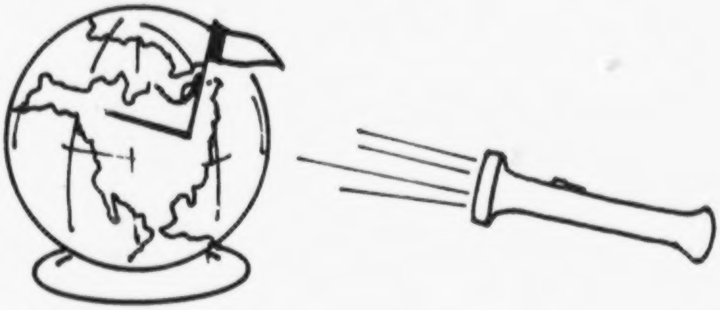
Objective: to discover the relationship between the rotation of the earth and day and night.

Materials: Flashlight or other strong light source. Globes. Small human figure or flag.

Procedure: Fasten the figure or flag straight out from the globe with clay or adhesive. Hold the light stationary and shine it at the globe as you rotate it.

Have the students observe what happens as the globe rotates slowly. What happens to the shadow of the figure or flag on the globe? Observe shadows of poles or trees or your own shadow during different times of the day. How are the shadows on the globe like those you observe in real life?

What does the flashlight represent? If Earth is approximately 25,000 miles around, how fast would an airplane have to travel to remain in sunlight for 24 hours? In what direction should the pilot fly? Why do you think so? What kind of plane could do this? What special problems would a plane encounter in doing this?



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PLANETS IN ORBIT I

Objectives: to discover that centrifugal force can overcome gravity; to show that centrifugal force depends on velocity; to show that the greater a planet's distance from the sun, the slower it moves.

Materials: Chalkboard erasers (3). 32 inch string. Spool.

Procedure: Fasten one of the erasers to the string and drop the string through the empty spool. Fasten two erasers to the other end of the string.

Hold the single eraser out from the spool, parallel to the floor. Let go. What happens? Why?

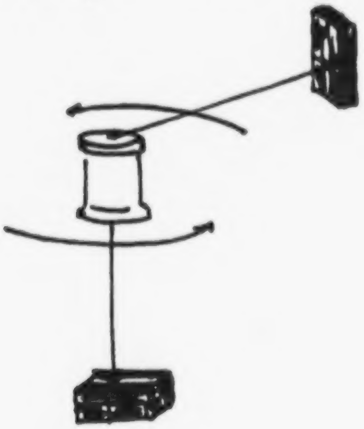
Start as before but whirl the eraser slowly this time. What happens? (Centrifugal force, or the force of inertia of motion is overcoming the pull of gravity.)

Increase the speed of the orbiting eraser. What happens? (The two erasers will lift.) Slaken the velocity. What happens? Why? A change in velocity produces what? How does this relate to planets in orbit?

Have students count revolutions in equal time periods with eraser at different distances from spool. Compare the results. What does this say about the effect of a planet's distance on its speed?

Have a student add extra erasers to the suspended erasers one at a time and whirl orbiting eraser to bring erasers up to a fixed distance from the floor. Count revolutions. Graph data and compare velocities for different weights. What does the experiment tell the students about the effect of greater weight (greater gravitational pull) on the orbit of an object?

Extension: After the following activity, have students note the orbital speeds of the nine planets. Compare with data from the above activity.



SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Demonstration

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Orbit
Centrifugal force
Velocity
Relative motion

SKILLS:

Observation
Drawing conclusions
Identification and control of variables

RESOURCES:

133, 147, 160, 180

48

PLANETS IN ORBIT II

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Expository
Guided Discovery

CONCEPTS:
Orbit
Variables of speed and distance

SKILLS:
Computation
Inference
Drawing conclusions

RESOURCES:
133, 142, 156

Objective: to better understand the planets revolve around the sun at different speeds and at different distances.

Materials: Paper. Pencil. Worksheet. (next page)

Teacher Background Information: Each planet moves around the sun at different speeds and at different distances. The greater the planet's distance from the sun, the slower it moves.

Mercury, Venus, Earth and Mars are often referred to as the inner planets because they are closer to the sun. Juniper, Saturn, Uranus, Neptune and Pluto are sometimes referred to as the outer planets. The orbits of these planets are billions of miles greater than that of Earth and so their "year" is much greater than Earth's.

The time it takes each of the planets to make one complete trip around the sun, rounded off to the nearest complete Earth year, is given on the worksheet following.

Procedure: Put the chart on chalkboard or overhead projector. Point out the planets on a model of the solar system, if you have one. Have students note carefully that the chart computes the inner planets in earth days and the outer planets in earth years. (You may want to play with the multiplication involved in converting the chart to either days or years for all planets.)

After a discussion on the effect of distance from the sun relative to speed or orbit, have students complete the worksheet on the following page.

Answers to worksheet:

1. a-140 b-277
2. a-137 b-462
3. 1 year and 322 days
4. 4 + Mercury years
5. Longer
6. Earth
7. 599
8. 81
9. 83
10. Saturn and Uranus
11. Pluto

PLANETS IN ORBIT WORKSHEET

Using the information given below, answer the questions which follow.

Mercury	88 Earth days
Venus	225 Earth days
Earth	365 Earth days
Mars	687 Earth days
Jupiter	12 Earth years
Saturn	30 Earth years
Uranus	84 Earth years
Neptune	165 Earth years
Pluto	248 Earth years

1. How many more Earth days does it take Earth to complete its orbit than
   a. Venus? b. Mercury?

2. What is the difference in Earth days between the orbits of
   a. Mercury and Venus? b. Venus and Mars?

3. The orbit of Mars takes how many Earth years and days?

4. If we think of a year as the time it takes for a planet to make one complete orbit, one Earth year would be equal to about how many Mercury years?

5. Is a Mars year longer or shorter than an Earth year?

6. Which planet comes closest to having a year that is half that of a Mars year?

7. How many more Earth days would have to be added to Mercury's orbit to equal a Mars year?

8. How many Earth years would have to be added to Uranus' orbit to have it equal to Neptune's?

9. Pluto's orbit is greater than Neptune's by how many Earth years?

10. Among the outer planets, two have "years" that are about 2½ times that of neighboring planets. Which pair of planets are they?

11. Which outer planet has an orbit that is about one and a half times as long as its nearest planet neighbor?

49

SUN SIZE

Objectives: to understand the relationship of the sun, earth and moon during an eclipse; to understand relative size and distance of sun and moon.

Materials: 1-one gallon jar. 1-1/2 pint jar. 1 Large beach ball or basketball. Marble.

Background Information: An eclipse occurs when either the earth blocks the light of the sun from the moon or the moon blocks the light of the sun from the earth. The moon is about 2,000 miles in diameter while the diameter of the sun is about 865,000 miles.

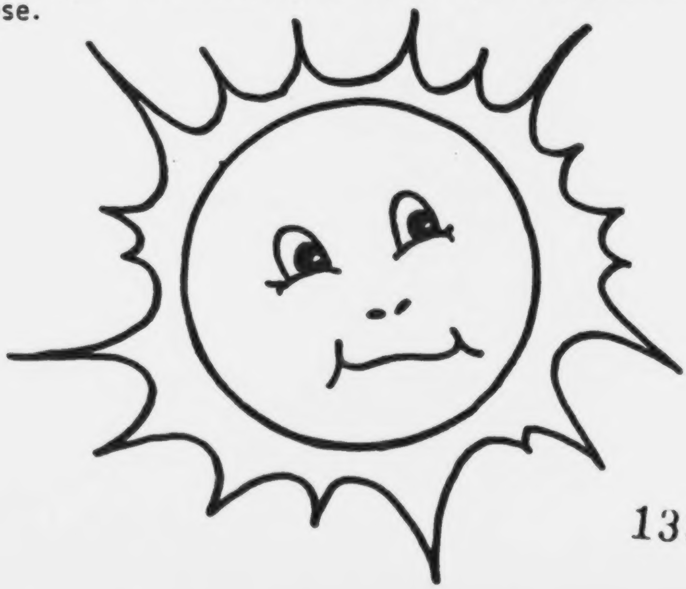
Procedure: Place the gallon jar in view of your room, about 200 feet from the school building. Hold the 1/2 pint jar in front of the class and point out the jar outside. Ask which jar is larger of the two.

Have one of the students retrieve the gallon jar and then discuss the comparative size of the two jars. Talk about the relevance of this to the size of planets in the solar system.

Using the large ball and marble, relate the sizes of the spheres to the sun and the moon, Have a pupil (A) hold the marble between two fingers and at arm's length. Have a pupil (B) stand about 5' from pupil A and hold the large ball at eye level.

Pupil B should move to the proper distance from pupil A to have the marble just block off the large ball. This is an eclipse.

Have pupil A move the marble closer to and farther from his eye. Discuss the effect of this movement on the eclipse.



SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Demonstration

TEACHING STRATEGY:

Expository and
Guided Discovery

CONCEPTS:

Eclipse
Relative size
and distance

SKILLS:

Observation
Inference

RESOURCES:

133, 138, 164-169, 180

50

HOT, HOTTER, HOTTEST

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository

CONCEPTS:
Indirect evidence
Measurement of temperature

SKILLS:
Observation
Inference
Data collection/recording

RESOURCES:
148, 162, 298

Objective: to help students understand that stars have different temperatures and how those temperatures can be determined.

Materials: Pliers. Iron nail. Candle. Thermometer. Magnifying glass. Unshaded light source.

Procedure: Hold an iron nail with a pair of pliers in a candle flame. Have students note what happens as the nail gets hotter. Explain that astronomers compare the colors of stars to heated objects here on earth in order to estimate their temperatures. Ask if they can guess what color our sun is. (Yellow, by golly.) (Was our sun ever blue-white? Will it ever be red?) Explain that the hottest stars are a blue-white color, that cooler stars are yellow and that the coolest stars are red. How does that compare with what happened to the nail as it became hotter?

Ask a student to hold a thermometer about 30 cm away from an unshaded light bulb. Have another student record the temperature. (Give it about 3 minutes before recording.) Hold the magnifying glass so that the light focuses directly on the bulb of the thermometer and, after three minutes, record the temperature again. Discuss what the students observe. Repeat the measurement at ever greater distances from the bulb. What happens? Have students record and graph their data showing the relationship between the distance in cm and degrees in temperature. Ask if they can relate this to how astronomers might measure the stars' temperatures. (You may have to explain that astronomers use the lenses of telescopes as well as other sensitive instruments to measure the temperature of stars from here on earth.)

Extension: Discuss with students why most all of our information about the characteristics of the universe is indirect. Talk about how that is changing with new explorations and moon walks and probes. What is "wrong" with this statement, printed in a Science text in 1978, for example: "Saturn has 10 moons." Discuss the notion that scientific evidence is sometimes temporary and the responsibility of people is to be open to new evidence.

51

ASTRONOMICAL ANSWERS!

Objectives: to assure the students' awareness of astronomy; to motivate students to investigate information on the solar system.

Materials: Copies of the questions from the "Basic Astronomical Knowledge" test. (see following pages) Books of Astronomy.

Procedure: Distribute a question from the "test" to individual students or to partners. Explain that each question will be shared with the class after an answer for it has been found. Explain the importance of conveying accurate information and relating how you are sure it's true. Science information changes rather rapidly at times (i.e., look what's happened to our information explosion regarding Saturn recently) and the dates on material and the reliability of the experts should be examined.

Explain to the class also, that once they have found their "answer," they should take the time to gather a bit more information on their subject just for fun. When they share their question and answer, they can present whatever else they have gathered for the class including questions that have occurred to them). Encourage them to bring the books they found material in as well as pictures or diagrams.

Note: You may distribute the questions by making copies of the test, cutting the individual questions out and putting them in a hat for random distribution. If there are kids in the class who may panic at some of the more involved questions, you may want to assign questions according to interest or ability.

Ask what role aviation and/or space exploration plays in our knowledge of the solar system (air borne telescopes, space probes and earth satellites, for example.) Reminder: Our Earth is part of the solar system. Talk about exploring our own planet from space.

SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Individual or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Astronomy

SKILLS:

Problem Solving
Researching

RESOURCES:

131-133, 135,
139-180

THE BASIC ASTRONOMICAL KNOWLEDGE TEST...

1. On which day(s) of the year does the sun appear straight up - directly overhead - from locations in the continental United States?

2. On which day(s) of the year does the sun rise due east?

3. How does the sun produce its energy?

4. If the sun were the size of a thumbnail, where, to scale or in exact proportion, would the nearest star be?

5. What is the brightest star in the night sky?

6. Of the stars we see in the night sky, how many are part of the Milky Way galaxy?

7. Approximately how many stars are in our galaxy?

8. Why does our sun look so different from the stars at night?

9. What is the difference between an astronomer and an astrologer?

10. Which planet is closest to the sun? Farthest? How do they line up in between?

11. Which planet is (environmentally) most like the Earth?

12. Which planet is most like the sun? (In terms of composition)

13. Which planet(s) have rings?

----

14. Which planet is the smallest? Largest? How do they line up in between?

----

15. Where do the stars go in the daytime?

----

16. Which best describes the sun? a) it is a bright planet b) it is an average star c) it's similar to the Moon but brighter d) astronomers really don't know how to describe it

----

17. Which best describes a comet? a) a large dirty iceberg b) a glowing ball of gas c) a star streaking across the sky near the Earth d) a rock burning up in the Earth's atmosphere

----

18. Can the moon be seen in the daytime? Explain.

----

19. Which best describes a falling star? a) a large dirty iceberg b) a glowing ball of gas c) a star streaking across the sky near the Earth d) a rock burning up as it enters the Earth's atmosphere

----

20. What is the moon's period of revolution around the earth?

----

21. What is the Earth's period of rotation?

----

22. What is the Earth's period of revolution?

----

23. On what day of the year are night and day nearly the same length?

----

24. When is the first day of summer in the United States? a) when the Earth is closest to the Sun in its orbit b) when the northern hemisphere is tilted toward the Sun d) when the Sun is directly overhead at noon d) both a and c

52

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Large

TIME:
30-40 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository
Guided Discovery

CONCEPTS:
Inertial Guidance

SKILLS:
Observation
Inference

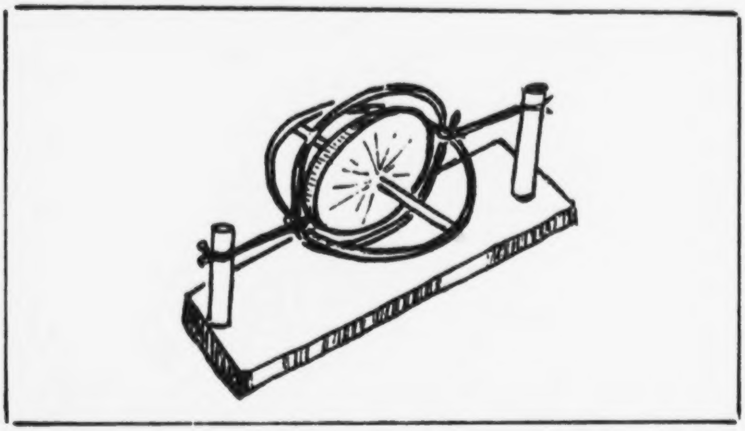
RESOURCES:
40, 104, 108, 231

Objectives: to observe and identify some of the properties of a gyroscope; to identify instruments used in flight which make use of the properties of the gyroscope.

Materials: One or more toy gyroscopes. A small wooden stand (as in picture). 2 elastic bands or string.

Teacher Background Information: In an aircraft, an indicator attached to the gyro mounting senses changes in attitude and velocity and indicates the required corrective measures. A three-gyro inertial system, used in many of the more advanced vehicles, is mounted so that the sensitive axis of each gyro is perpendicular to each of the others. Through this system, it is possible to detect all of the vehicle's movements, such as yaw, pitch, and roll.

Procedure: The toy gyroscope can be used to illustrate the principle behind the instrument which detects undesirable motions in launch vehicles and helps to stabilize many spacecraft while in orbit. With small elastic bands tied to its side cross-frame, mount a gyroscope in a wooden stand, as illustrated below, so that it will swing freely. When the wheel is spinning rapidly, turn the wooden base and note how the gyro tilts. How can this phenomenon be used to indicate position? Discuss where to look for information on instruments in aircrafts which use a gyroscope. Have students do a little research and share their findings.



53

USING REFERENCE OBJECTS

Objectives: to have the students use reference objects to describe the position of objects or places; to help students understand the term "landmark" as a reference object.

Materials: "Aerial Map" worksheet. Maps of the area (School district may have them.)

Teacher Background Information: Pilots, as well as others using a map to get from place to place, look for landmarks to verify their position. Help the student learn to identify landmarks with the help of the "Aerial Map", by talking with them about the landmarks on maps of cities and states or by going outside to the school grounds and identifying landmarks there, using them to give directions from one place on the grounds to another.

Procedure: Using the worksheet, locate the landmarks on the "Aerial Map." (Airport, railroad tracks, river, roads, intersections, bridges, mountains, trees, castle, lake, island) Help students understand that, from the air, names of roads or rivers are pretty much irrelevant but the relative position of a road to a railroad track, for example, might be very meaningful in finding the location the pilot desires.

After the landmarks are clear, ask a student to pretend s/he is at point F (going due North) in an aircraft without a working compass and wants visual directions to a landing field. Have a second student choose a specific landing field without telling the pilot which one it is. Have the second student give directions using the landmarks as reference objects until the direction giver says the pilot should be at the designated landing field. See if s/he is.

After the students have tried it with the "pilot" unable to communicate back to the direction giver, repeat the procedure with students starting in various places going to unknown destinations but able to check where they are when they choose. Talk about the pitfalls of imprecise language and the need to clarify their location along the way.

Extensions: A. The aerial map can be used to write specific directions in the same way or it can be used with the compass in the aircraft working so that directions using the compass can be written.

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Small or Large

TIME:
50-60 minutes

TYPE OF ACTIVITY:
Simulation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Relative position
Landmarks
Reference objects

SKILLS:
Observation
Describing

RESOURCES:
97, 101, 104,
298

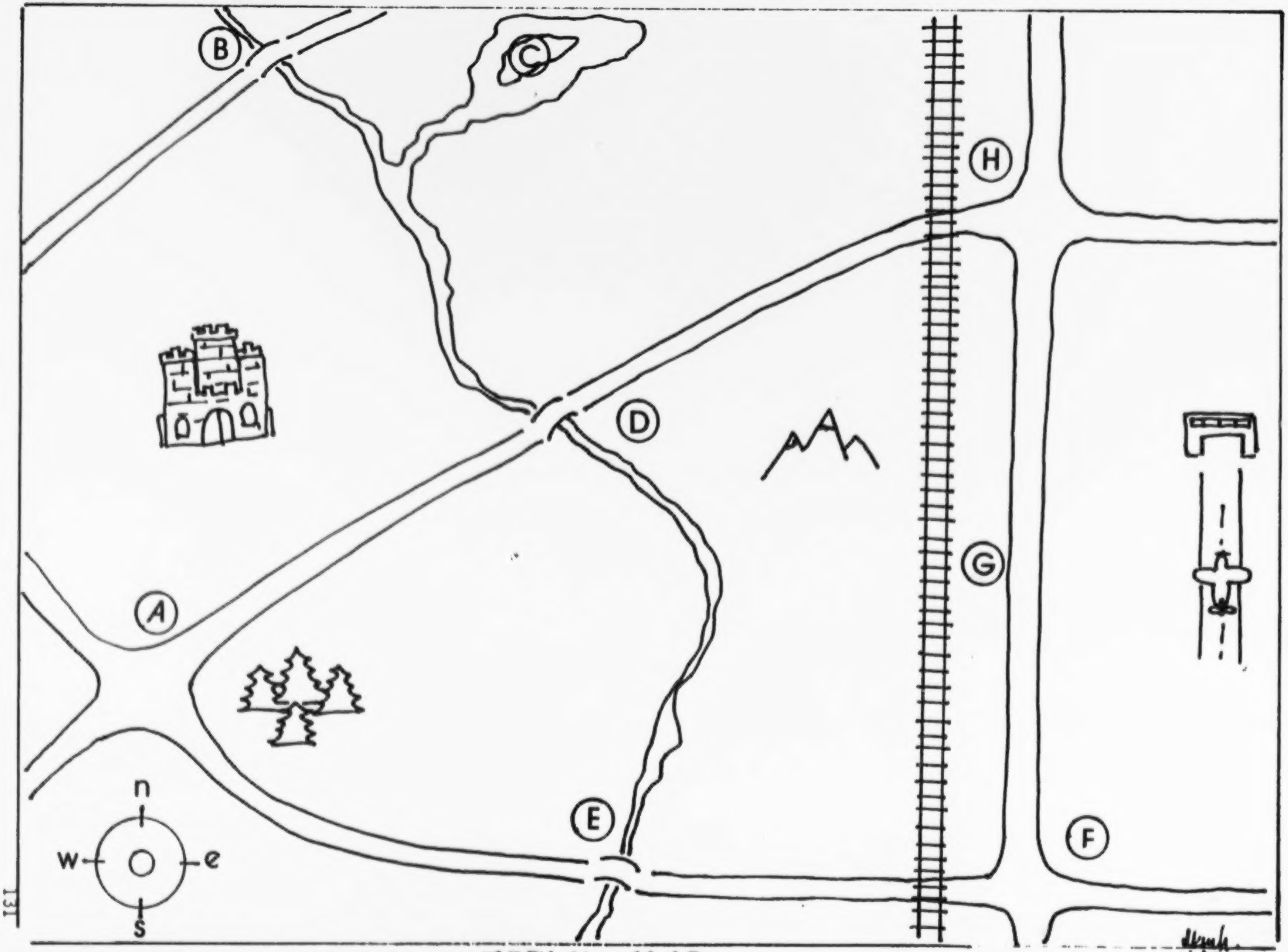
USING REFERENCE OBJECTS (continued)

B. Have students make their own "aerial map" of their area - the neighborhood they live in with schools or parks or buildings, for example, noted as landmarks. Have students write specific directions from their home to various points using the landmarks.

C. Get a map of your city or a large area around your town and locate the landmarks. Have students mark them on the map. Encourage the students to add new landmarks as they walk or ride around the area and discover new ones. See how students do on directions from one place to another.

D. Add a scale for kilometers or miles (or both) to the "Aerial Map" and have students write directions using compass directions and distance.

E. You might want to play with the idea of adding to size of the mountain (both in width and height) or adding high tension wires in front of places to land or a mountain range around part of another and see what kinds of modifications in directions the students give.



AERIAL MAP

54

POLAR COORDINATES

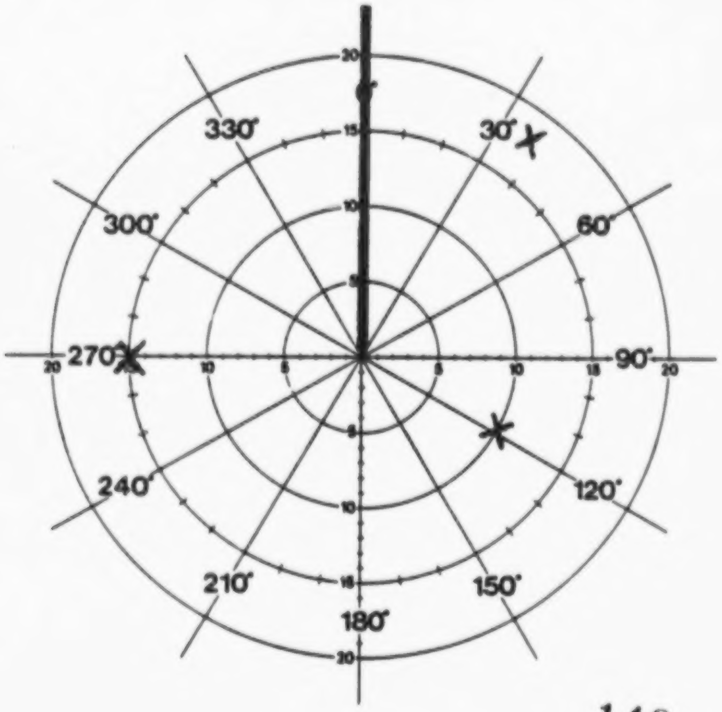
Objective: to describe and locate the position of objects and places using a polar coordinate system.

Materials: Copy of grid for each student. Pencils. (Optional: Small pictures.)

Teacher Background Information: Previous lessons dealt with position of objects or places in a general way. A more precise method is used by pilots who must navigate to a specific place. One of the methods uses polar coordinates. These coordinates are the equivalent of longitude and latitude on a map.

To describe the position of an object or place using polar coordinates, a reference point must be used from which to start. This point, technically the "origin of coordinates," can be called the starting point or place of origin.

Two coordinates are used to describe position from a starting point. First, the direction from the starting point is given in degrees like a compass direction. The numbering begins at the 0 point, North on a compass, and proceeds clockwise around a circle. (See illustration).



SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

30-40 minutes

TYPE OF ACTIVITY:

Demonstration and Student Activity

TEACHING STRATEGY:

Expository

CONCEPTS:

- Direction
- Distance
- Relative position
- Polar Coordinates

SKILLS:

- Interpreting data
- Using maps

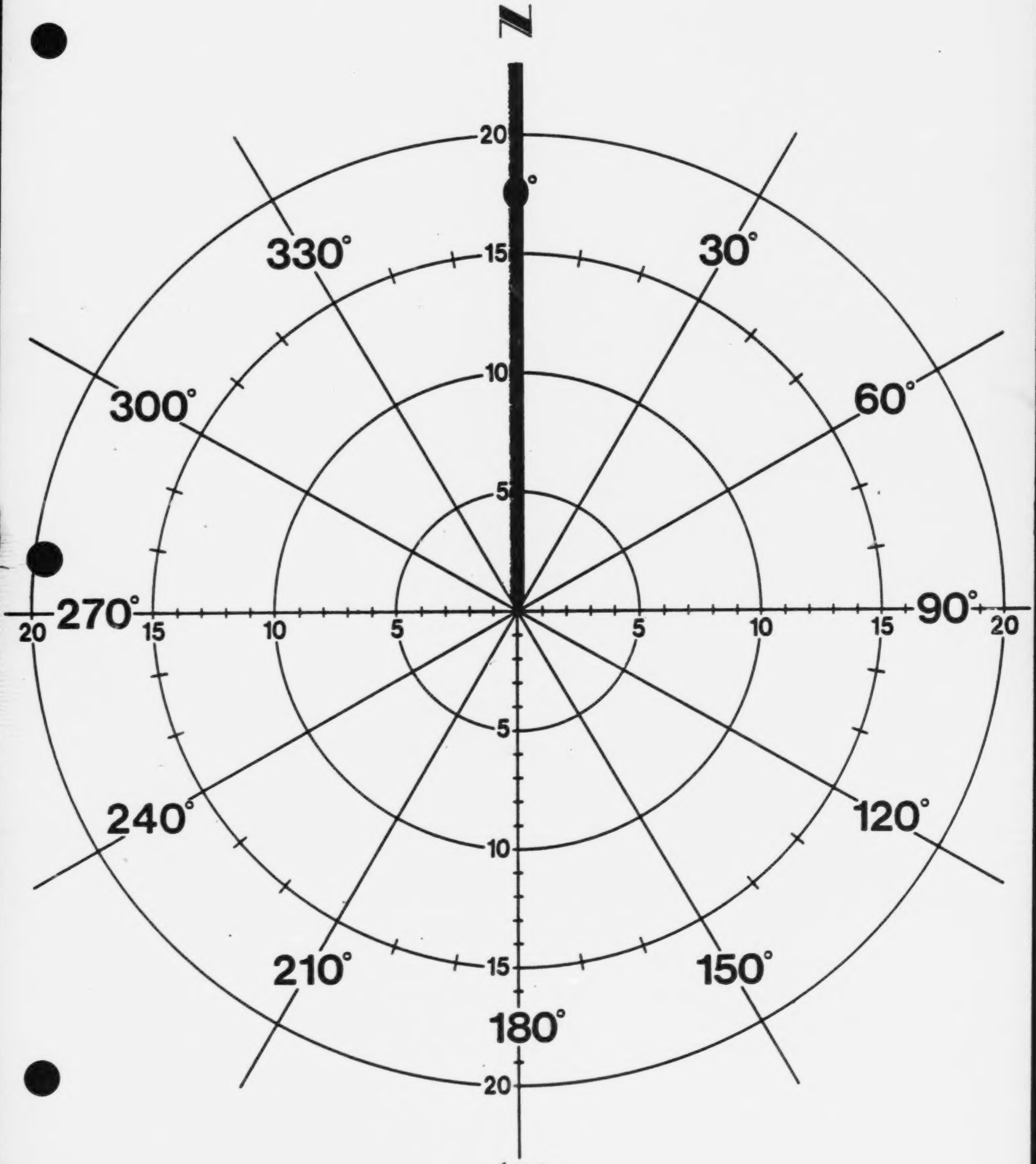
RESOURCES:

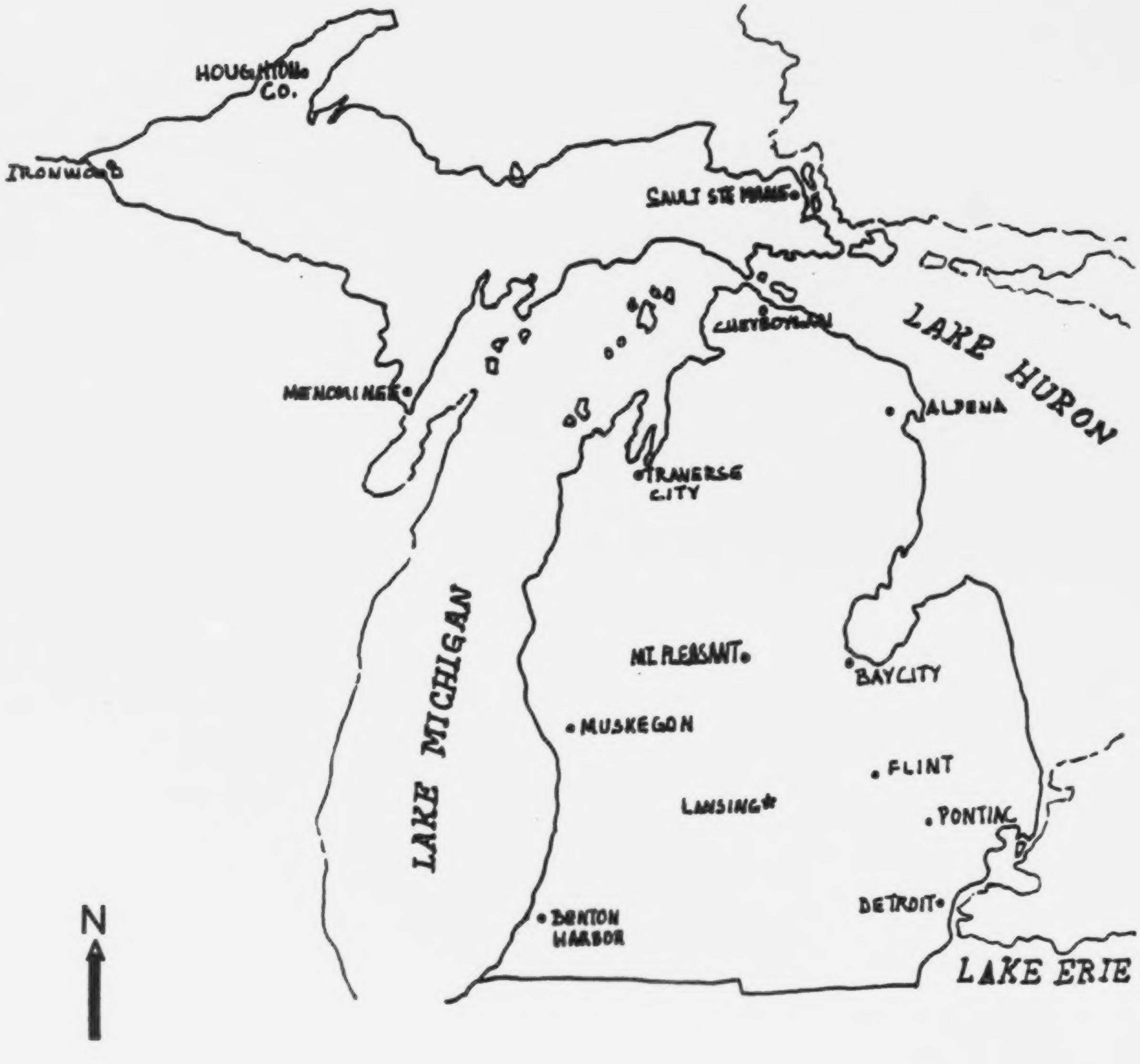
95, 121, 298

Second, the distance from the starting point must be given. This is expressed in some standard unit such as meters, kilometers, paces, miles, etc. or simply as "units." The two coordinates are expressed as a number pair in parentheses: first, the direction and second, the distance. (120°, 10 units) or 270°, 15 units) or (37°, 18 units). These positions are marked on the illustration with x's.

Procedure: Make copies of the large grid (see following page.) Have students mark several x's on the polar grid wherever they choose or have them paste small pictures on the grid in various places. The teacher can use a large example at the board if desired. Explain the system to the students and have them try to describe the position of the picture or x's on their grid or on the teacher's large grid.

To reinforce the concept, play "Secret Code Game." Using a copy of the polar grid, place the letters of the alphabet and sentence closures such as a question mark, a period or an exclamation mark on the grid at various positions. Make a message for the students to decode using the proper coordinates as the code for the appropriate letter. The students can then code their own messages for the class to decode.


N
0°
330°
30°
300°
60°
270°
90°
240°
120°
210°
150°
180°
20
15
10
5
5
10
15
20
20
15
10
5
5
10
15
20


HOUGHTON CO.
IRONWOOD
SAULT STE MARIE
CHEYBOYGAN
LAKE HURON
MENOMINEE
ALPENA
TRAVERSE CITY
LAKE MICHIGAN
MT. PLEASANT
BAY CITY
MUSKEGON
FLINT
LANSING
PONTIAC
DETROIT
BENTON HARBOR
LAKE ERIE
N

55

POLAR COORDINATES AND FLYING IN MICHIGAN

Objective: to locate the position of airports and towns using a polar coordinate system.

Materials: 3 or 4 transparancies (depending on number of students in your small group) of the polar grid used in previous activity. Pencils. Aeronautical map. (Michigan Aeronautical Commission has them).

Procedure: Make enough transparancies for each pair of students in your small group. Have the students place the grid over the drawing of Michigan found on preceeding page. Have them begin by putting the point of origin over Mt. Pleasant. Have the students then place 0° to the North. What is the direction of Traverse City? (330°) How many units away is it? (About 6) What direction and how many units away is Alpena? (30°, 8 or 9) Do several cities until it is clear that all the students have understood the idea.

Give each group an aeronautical map and let them examine it for awhile. They will want to take a look at the legend and find some of the objects described. Have them find the airport nearest their town or city and map a flight to several other airports and return to their starting point. The students should begin with their grid centered on the airport nearest them and move the grid to the next airport as the "landing spot" and take a new direction reading to the next landing spot. Remember to keep 0° to the North.

As the students map their flight, have them record the polar coordinates for the airports they land on and the city or town nearest the airport. When they have finished, they can give the coordinates to another student as a game for finding the appropriate town or city near the coordinates. It might be fun to write a story involving a pilot - sleuth who tracks a jewel thief from airport to airport or a pilot-detective tracking a witness to a train robbery etc., using the coordinates so the students have to play detective to find the cities and the loot.

Extension: The SCIIS science program has an airport coordinate race in the Level 4 book which would be fun for the students to play while reinforcing the concept of polar coordinates.

SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Small (in pairs)

TIME:

45 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Direction
Distance
Relative position
Polar Coordinates

SKILLS:

Interpreting data
Using maps

RESOURCES:

96, 100, 103,
104, Aeronautical map

56

COMPASS ROSE

SUBJECT:
Science

GRADE:
Fourth

GROUP SIZE:
Large

TIME:
60 minutes

TYPE OF ACTIVITY:
Game

TEACHING STRATEGY:
Expository

CONCEPTS:
Compass
Directions

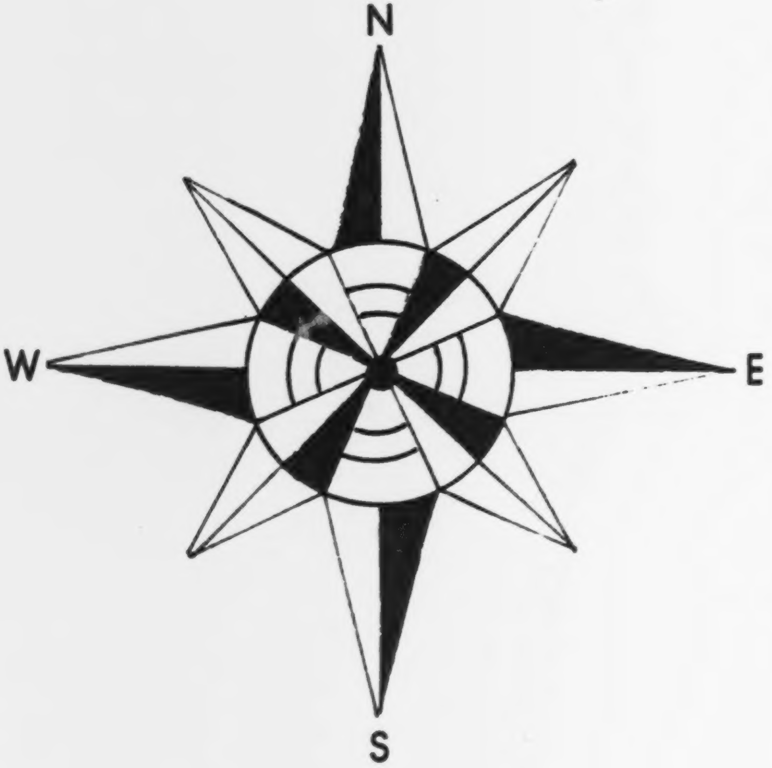
SKILLS:
Use of the compass

RESOURCES:
101

Objective: to help children gain an understanding of cardinal directions in terms of the compass.

Materials: Large sheet of butcher paper. Game sheet.

Procedure: Using the following two pages of illustrations and directions, draw a large compass on the piece of butcher paper. Read "The Game" directions and get at it. EXPECT CONFUSION at first. Do it with the students. Discuss how pilots of various aircraft use compass headings and why it is so vital that all persons involved use the same terminology.

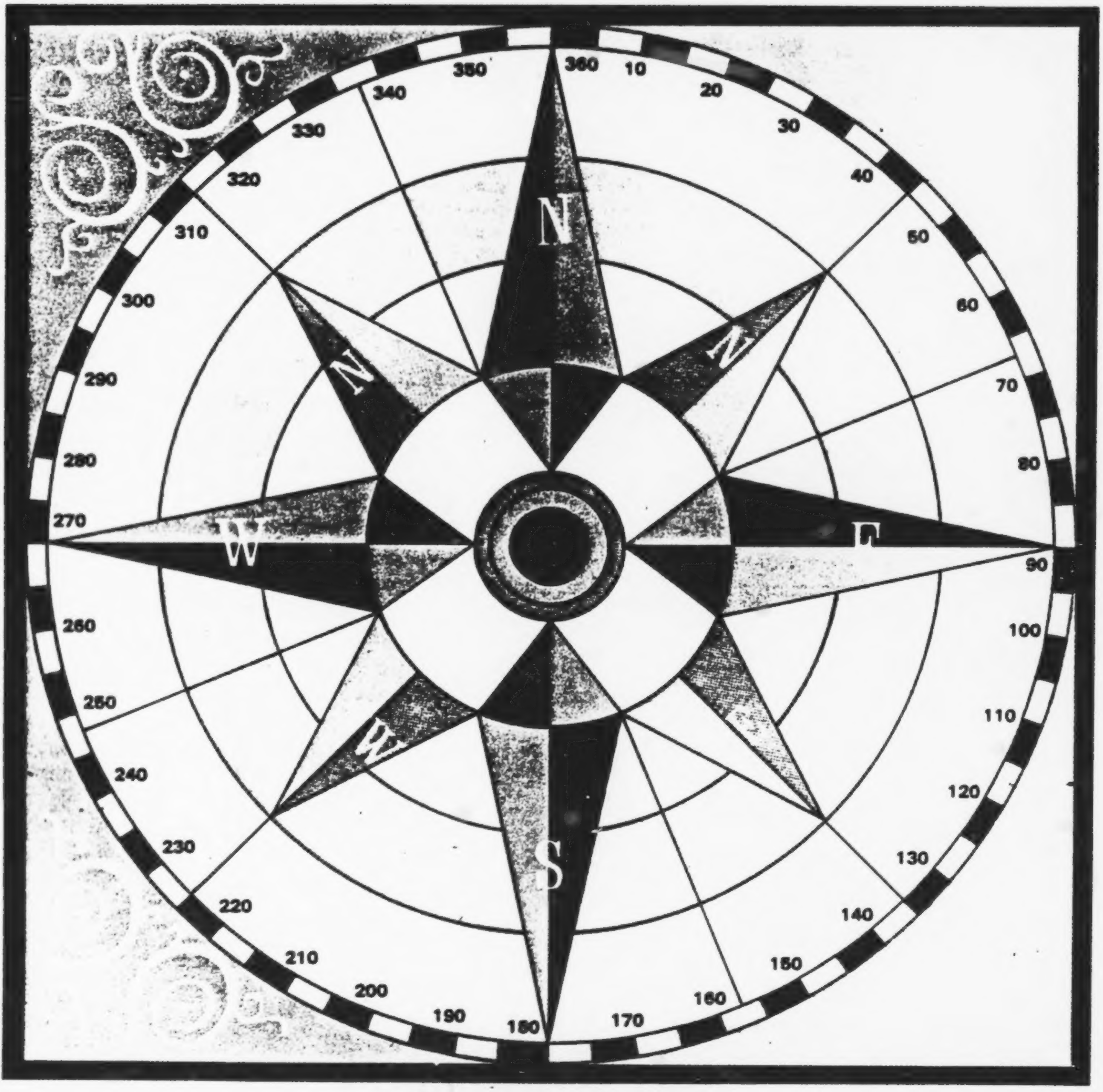


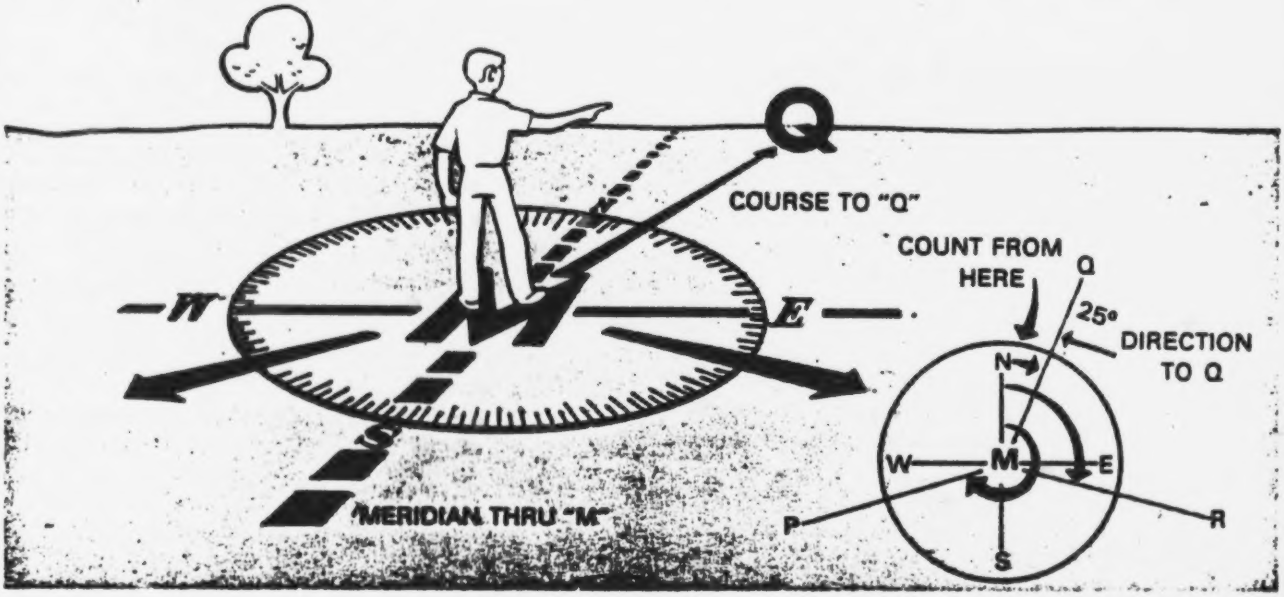
The Compass Rose Game

A SUGGESTED TEACHING STRATEGY

Basic to understanding maps and their application to finding one's way on the earth's surface is a thorough knowledge of the compass. From the ancient mariners to today's private pilots, the compass utilizing the magnetic north pole has been the primary instrument of navigation.

This "game" or activity is designed to help the children gain a basic understanding of cardinal directions in terms of the compass, and to refine that knowledge into understandings of the circle, angles, the great circle routes, and skills in identifying compass directions.





The direction from any given point on the earth's surface to any given point on the earth's surface is always measured as a certain number of degrees from north. One nautical mile is equal to one minute of arc at the equator and on all the lines of longitude. Sixty minutes of arc is equal to one degree.

The Game

Draw a large compass rose on a large piece of butcher paper, or draw with chalk directly on the floor. Have north, or 360°, correspond to actual north. Mark the center of the compass rose where a child will stand.

Divide the class into teams, and let each member of each team take turns standing in the compass rose. Members of the other team can call out compass headings from 001° (one degree) to 360° to the child standing in the center of the compass rose, who turns and faces the direction called for. He must turn to his **right** to be correct, since degrees are counted from north to east to south to west to north.

Variations on this activity can be made to be appropriate to several ability levels. For example, some children can face a given direction and be directed to turn **right** or **left** a given number of degrees. If he is facing 035° and is directed to turn left 020° , he will turn left and be facing 015° when he stops. Or he can face 280° and be directed to make a 180° right turn. When he stops he will be facing 100° .

NOTE: In writing compass headings in numbers, one always writes three digits. If the compass heading is from one to nine, it is written 001° , 002° , 003° , etc. For headings over one hundred, no zero is placed before the number, as 180° , 283° , etc.

Orally, these directions, as they may be given to a pilot by a traffic controller on the radio, would be read "zero-zero-three degrees," or "zero-one-five degree", or "two-seven-zero degrees". Have the children use this terminology in performing the activity.

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57

PROBING THE EARTH

Objectives: to practice plotting longitude and latitude landing sites on a map of Earth; to draw conclusions about the Earth based on information gathered by simulated probes.

Materials: Study Sheet. Pencils.

Teacher Background Information: Scientists base some of what they know about other worlds upon the information gathered by probes which have landed on those worlds. The landing coordinates used in the exercise are those of the different lunar landings.

Procedure: Review with the students how to find latitude and longitude on a map. Playing the game "Battleships" can help.

Have students plot the landing points given on the study sheet. (next page)

What might a person gathering information at these landing sites conclude about the Earth? What does this say about data collection? About making generalizations?

Extension: Using the ceiling in your classroom as the "map" (If you have a suspended gridded ceiling already, you're in LUCK) plot longitude and latitude lines overhead. Decide, with your students, which meridian line will be the Prime Meridian and which parallel will be the Equator. Mark them as 0^{o} and then plot the meridians and parallels on either side in degrees of your choice (5^{o}, 10^{o}, etc.) You can use construction paper numbers stapled to a suspended ceiling or hung from it, whatever seems to work best. After the ceiling as been given its grid system, have students plot the coordinates where they sit, where the desk is, where various objects in the room are located. If the coordinates were given to an extra terrestrial to probe for a good idea of what your classroom was like, what coordinates and how many would have to be given? Talk about the need again, for sufficient data both in amount of sample as wellas in variety of sample.

SUBJECT:

Science

GRADE:

Fourth

TIME:

20-30 minutes

TYPE OF ACTIVITY:

Simulation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Coordinates
Probes
Latitude
Longitude

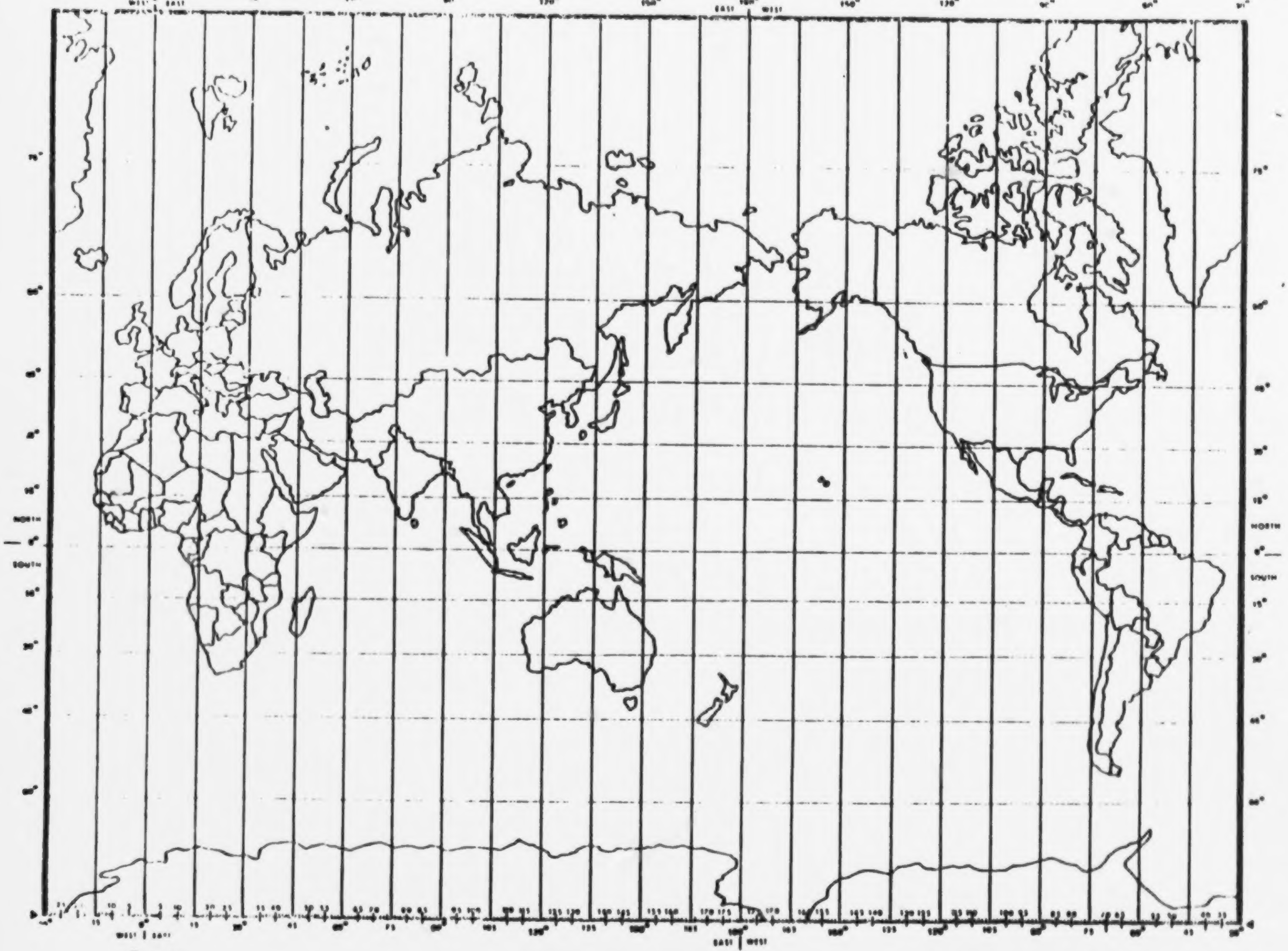
SKILLS:

Drawing conclusions
Plotting points
on a map

RESOURCES:

14, 216, 233, 291

ASSUME THAT THE MARTIANS HAVE SENT SPACE PROBES TO EARTH ... THE LANDING SITE COORDINATES ARE:

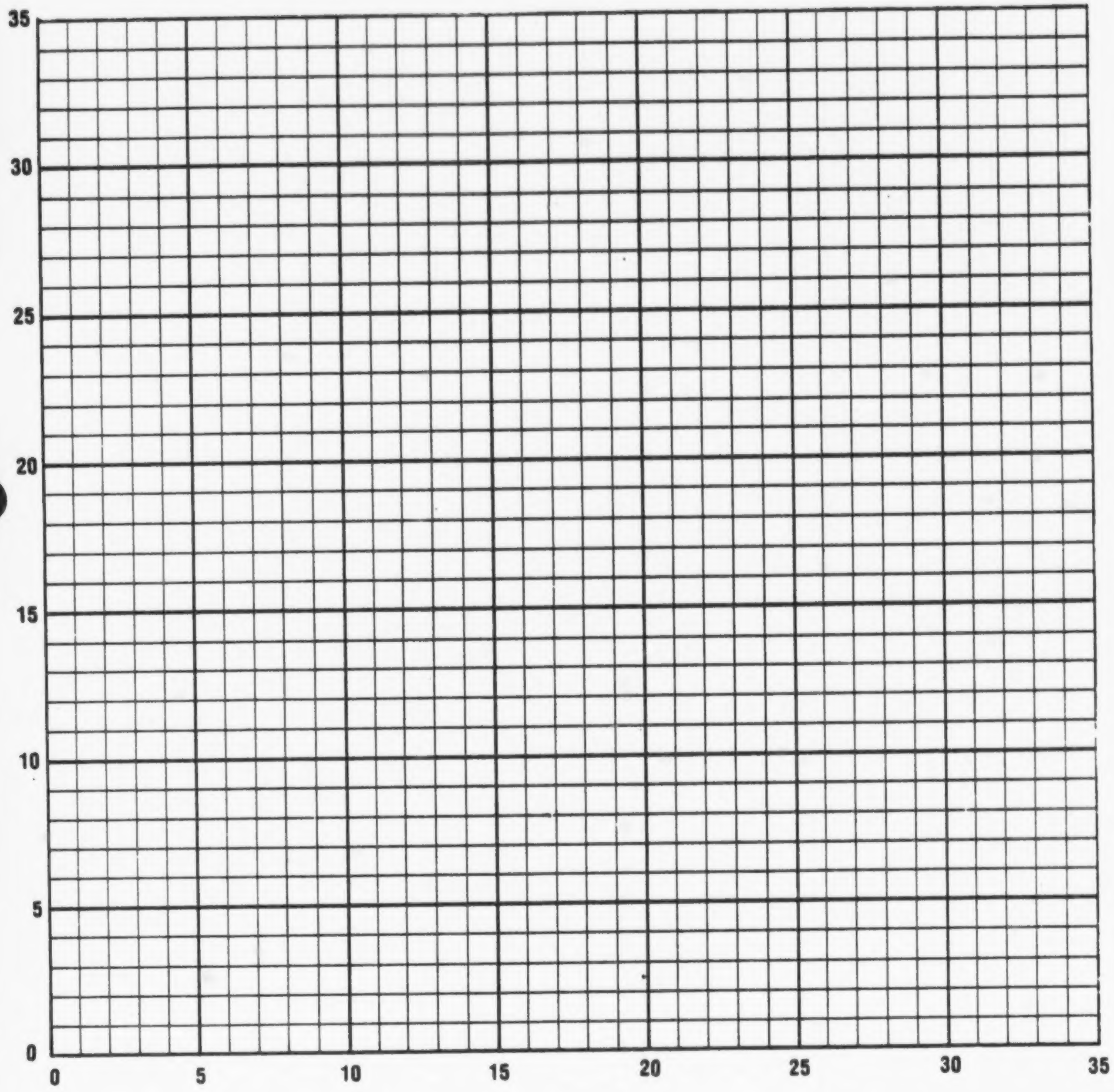


WORLD COVERAGE OUTLINE MAP

22°N	48°W
20°N	108°W
44°N	10°W
46°N	110°W
46°N	150°E
7°N	43°W
5°S	5°W

FROM THE RESULTS OF THESE PROBES, WHAT WOULD BE THE CONCLUSIONS ABOUT THE PLANET EARTH? WOULD THIS BE AN ACCURATE REPRESENTATION? WHAT DOES THIS TELL YOU ABOUT COLLECTING DATA?

BEST COPY AVAILABLE



Name__________________________________

58

RECTANGULAR COORDINATES

SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large or Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Demonstration & Game

TEACHING STRATEGY:

Expository & Guided Discovery

CONCEPTS:

Grid
Rectangular coordinates
Position

SKILLS:

Following directions
Graphing

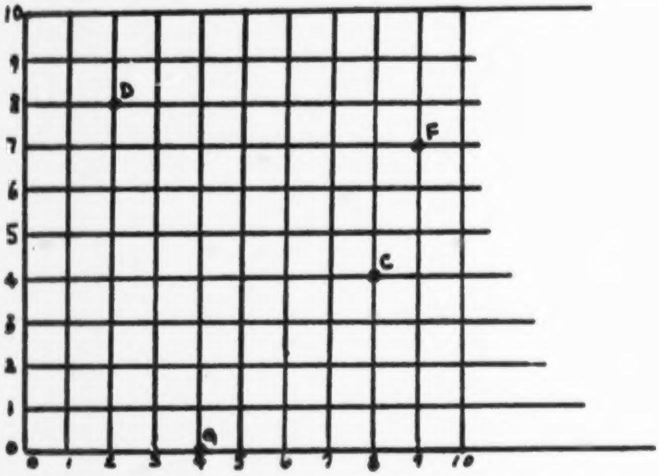
RESOURCES:

282, 298

Objective: to locate the position of objects using rectangular coordinates.

Materials: Graph paper. Pencils.

Teacher Background Information: Using ordinary graph paper, you can form a grid by numbering the lines as shown...



A point where two lines intersect is called a rectangular coordinate and can be designated by using the two numbers of intersecting lines. For instance, point C on the sample grid lies at the intersection of line 8 and line 4. The numbers (8,4) are the coordinates of point C.

Notice that the horizontal distance from the zero point is given first. This is universally accepted and avoids confusion. Remind your students often: horizontal first, vertical second.

Practice yourself with the other points on the graph. Point D is on a line over 2 and up 8 (2,8). Point G has the coordinates 4,0.

(Your students may know the game "Battleship" which uses rectangular coordinates to locate and sink hidden ships.)

Skills in using coordinates will allow students to use the technique to find positions on a map. Later, they can use the concept to understand how to locate their own position on a simulated flight using an aeronautical map.

Procedure: 1. Pass out graph paper and have the students number the lines on the paper to form a rectangular grid.

2. Have students place 3 "x's" on their paper where lines cross.

3. Now ask students to explain where they placed their "x's." They will probably suggest using the numbers on the grid to help describe where the x's are.

4. If they do not understand or use the number to describe the position of their marks, use a large grid on the board to show how the system works.

5. Label the concept, "Rectangular Coordinates." Explain that number pairs (i.e., 4,6) are used to name the coordinates of a mark on the grid.

6. Play the game "5 in a Row." The Game: Split the class into two teams. The object is to capture five grid points in a row along one grid line. The row may be formed left-right, up-down, or diagonally.

To capture points, the students take turns calling out rectangular coordinates and you mark on a large grid an X for one team and an O for the other team. The teams alternate calling out coordinates but only one student may call out a coordinate at a time and can receive no help from the team.

a. Two teams take turns capturing grid points by calling out coordinates.

b. The first coordinate is to the right, the second is up.

c. The teams may hold a one minute conference after each has had two turns.

d. If a point called out is already taken, the team's turn is lost.

e. The first team to capture five (5) points in a row is the winner.

59

PICTURES FROM SPACE

SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Simulation

TEACHING STRATEGY:

Expository

CONCEPTS:

Computer message

SKILLS:

Decoding
Graphing
Following directions

RESOURCES:

14, 216, 233, 268, 273, 277, 295

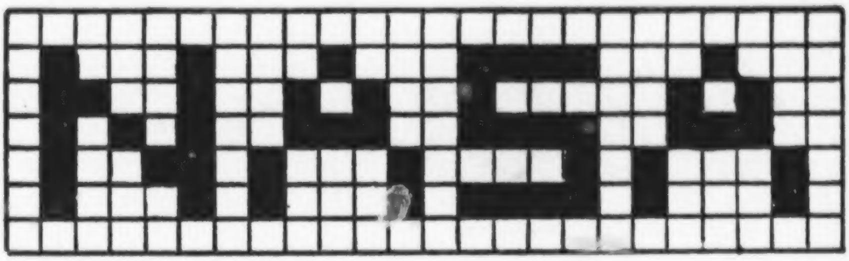
Objective: to help student understand how pictures from spacecraft can be received on Earth through the computer.

Materials: Activity sheet (next page) for each student. Pencil. Graph paper (24 x 7)

Procedure: Follow the "bleep, blip" code to form a message from space.

Ask students to make up their own space messages using the same "bleep, blip" code to put in an Acitvity Center for others to decode.

Suggest that they can produce images as well as messages this way. See what they come up with.



PICTURES FROM SPACE

1. Did you ever wonder how spacecraft like the Pioneer send pictures to Earth from distant planets? The sound of a picture returning from space is just a collection of strange "bleeps" and "blips." A computer is able to turn these sounds into a picture.

2. Follow the code below to make your own picture. Leave "bleep" squares blank and fill in "blip" squares with pen or pencil.

Row 1 bleep-bleep

Row 2 bleep-blip-bleep-bleep-bleep-blip-bleep-bleep-bleep-blip-bleep-bleep-bleep-blip-blip-blip-blip-bleep-bleep-bleep-blip-bleep-bleep-bleep

Row 3 bleep-blip-blip-bleep-bleep-blip-bleep-bleep-blip-bleep-blip-bleep-bleep-blip-bleep-bleep-bleep-bleep-bleep-blip-bleep-blip-bleep-bleep

Row 4 bleep-blip-bleep-blip-bleep-blip-bleep-bleep-blip-blip-blip-bleep-bleep-blip-blip-blip-blip-bleep-bleep-blip-blip-blip-bleep-bleep

Row 5 bleep-blip-bleep-bleep-blip-blip-bleep-blip-bleep-bleep-bleep-blip-bleep-bleep-bleep-bleep-blip-bleep-blip-bleep-bleep-bleep-blip-bleep

Row 6 bleep-blip-bleep-bleep-bleep-blip-bleep-blip-bleep-bleep-bleep-blip-bleep-blip-blip-blip-blip-bleep-blip-bleep-bleep-bleep-blip-bleep

Row 7 bleep-bleep

60

FORMING AN IMAGE WITH PIXELS

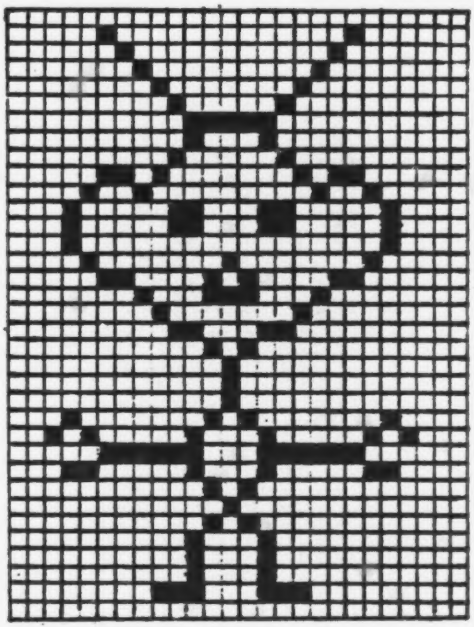
Objective: to simulate how images are transmitted from a satellite to the Earth.

Materials: Graph paper. Information sheet. (Following page) Pencils.

Teacher Background Information. Information about clouds, land features and Space data are sent to computers on the ground in the form of number values. The computer in turn constructs a picture from that data. This exercise gives students a chance to understand how that process works.

Procedure: Distribute the information sheet and graph paper to each student. Read through the directions on the information sheet with them and get them started on it. Let them work on their own until they can see the whole image of the space shuttle.

Extension: Have students make up their own set of directions for others to work out. These images can take the form of a picture or a written message. You might want to give them cryptic titles to work with like, "What We Saw When We Landed on Mars..." or "This is My Last Message from Space..." or "What Commander Harrison Observed in the Sky Over Pluto..." "What the Robot Saw..." etc. - FUN



SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

30 minutes

TYPE OF ACTIVITY:

Simulation

TEACHING STRATEGY:

Expository

CONCEPTS:

Pixels
Coordinates
Satellite images

SKILLS:

Decoding
Graphing
Interpreting data

RESOURCES:

227, 277

FORMING AN IMAGE WITH PIXELS

To form an image in a manner similar to the way in which Landsat, Voyager and other spacecraft allow us to form images, follow these instructions.

1. Beginning at the top left square of a sheet of graph paper, count four squares to the right and then fill in the letters of the alphabet in the squares across the top of the page.

2. Beginning at the same top left square, count down three squares and then write the numbers 1 through 39 in the squares down the side of the page.

3. Darken these squares: 1-n; 2-m,o; 3-l,p; 4-k,q; 5-k,q; 6-k,q; 7-i,k,q,s; 8-h,j,k,q,r,t; 9-g,k,q,u; 10-g,k,q,u; 11-g,k,q,u; 12-g,k,n,q,u; 13-g,k,m,o,q,u; 14-g,k,l,n,q,u; 15-g,k,q,u; 16-g,k,q,u; 17-g,k,q,u; 18-g,k,q,u; 19-g,k,q,u; 20-g,k,q,u; 21-g,k,q,u; 22-g,k,q,u; 23-g,k,q,u; 24-g,k,q,u; 25-g,j,r,u; 26-g,i,s,u; 27-g,h,t,u; 28-g,u,; 29-f,v; 30-e,w; 31-d,n,x; 32-d,n,x; 33-d,n,x; 34-d through x; 35-g,k,n,q,u; 36-g,k,n,q,u; 37-g,k,q,u; 38-h,j,r,t; 39-h,i,j,r,s,t.

61

COLORING YOUR OWN "LANDSAT"

Objective: to introduce the concepts of false color imagery produced by the Landsat satellite.

Materials: Worksheet of "Landsat images" (following page). Marker or Crayons. Landsat images.

Teacher Background Information: NASA's Landsat has produced thousands of images with its Multispectral Scanner for use in accessing flood damage, for forestry projects, land use assessment, mapping, conservation and ecology. The satellite is in polar orbit approximately 568-570 miles over the earth and orbits from North to South snapping pictures as it moves. Each image covers a region 115 miles (185 km) on a side and as the satellite snaps its pictures, it's computer sends pixel messages back to earth's computers for "developing."

The colors of the Landsat images appear somewhat strange because the image is produced by combining reflected near infrared light with red and green light. Thus, vegetation, for example, which looks green to us under normal conditions, will look red on a Landsat picture. This false color imagery - or a coded image - can be fed into the computer and coded in whatever manner the scientist or map maker then wishes.

It would be helpful to have full color Landsat images for the students to see. They are avaialbe from NASA, free to teachers. In the meantime, the worksheet can suffice as a fun beginning to an understanding of this rather complicated and immensely useful satellite.

(Planes can be used to take similar images. Since the planes that are used for this photography generally fly about 15 miles above the earth, it would be expected that the images would be even sharper and more detailed than those of Landsat. However, the Landsat images can cover far more territory and can be taken at all times since the satellite is in constant orbit.)

Procedure: Run off and distribute one worksheet to each student and tell them that Landsat images are provided in a similar manner. (For one thing, North in our images is directly Right of each image which is not true of Landsat images.) Have the students use the code and carefully color the four pictures as indicated. When they have each image color coded, have them cut out each image and piece together appropriately. (01's South end fits 02's N end, etc.) They should be encouraged to try to

SUBJECT:

Science

GRADE:

Fourth

GROUP SIZE:

Large

TIME:

40 minutes

TYPE OF ACTIVITY:

Simulation

TEACHING STRATEGY:

Expository and Guided Discovery

CONCEPTS:

False color imagery
Landsat

SKILLS:

Inference

RESOURCES:

216, 272, 273, 277

discern what this strip might be a picture of. If you have a real Landsat image of this part of Michigan, it might be fun to compare with the students' images. The Landsat images should show a much more detailed set of references. Features like cities, rivers, mountains, lakes, resevoirs, interstate highways and agricultural regions will frequently be seen. (The less cloud cover, the better, of course.)

Discuss the need for seeing such an overview in the event of various happenings: floods, infestation of disease or of insects in crops, forestry projects after fire or damage from hail, ecology and conservation.

Extension: The U.S. Department of the Interior will, upon request, initiate a computor search for imagery over an area of interest. For information, computor search forms and cost, call or write:

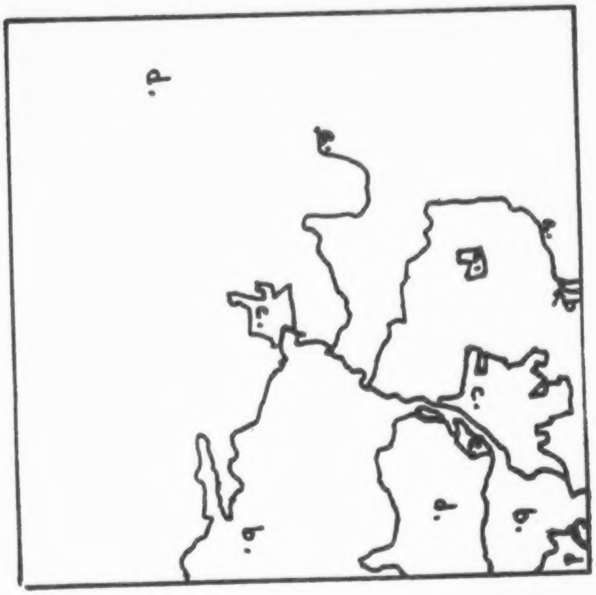
NCIC Headquarters
US Geological Survey
507 National Center
Reston, VA 22092
(703) 860-6045

Your students will have to use their knowledge of latitude and longitude as well as their letter writing skills to request data. After the images are delivered, you might want to initiate a discussion of the various uses the images could be put to in your specific area.

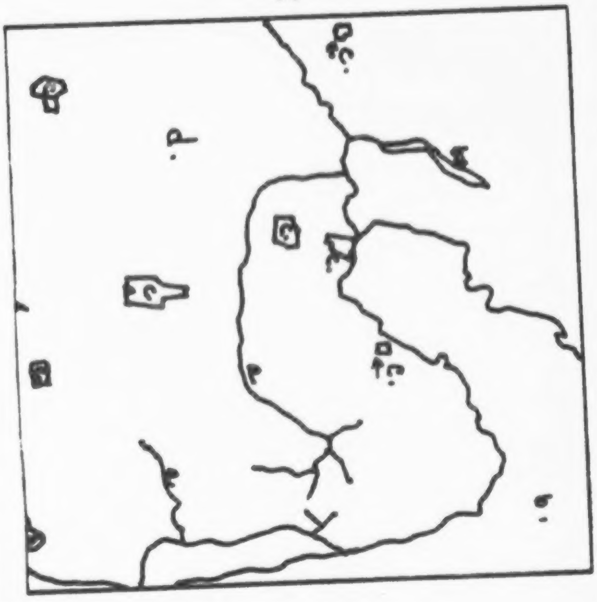
02

01

04



03



CODE:

a. Rivers - Black
b. Lakes - Dark Blue
c. Cities - Grey
d. Medium Vegetation - Orange
e. Heavy Vegetation (Forest) - Red

"WHERE THE CLOUDS ARE FAR BEHIND"

> "WHEN I WAS A BOY, I USED TO ASK SUCH SIMPLE QUESTIONS - LIKE, 'WHAT HOLDS THE CLOUDS UP?'"
>
> MURRAY GELL-MAN,
> PHYSICIST

62. PILOT TESTS
63. HUMAN REACTION TIME
64. LUNG CAPACITY TEST
65. GETTING THERE
66. CONSTRUCTING AN ACTION-REACTION ENGINE
67. BREAKING AWAY
68. ON STAGE FOR ORBIT
69. HITTING THE MOON
70. HOT UNDER THE COLLAR
71. MANUFACTURING WATER IN SPACE
72. GETTING DOWN IN EGGSACTLY ONE PIECE
73. NEUTRAL BUOYANCY
74. REDUCING YOUR WEIGHT (ON THE MOON)
75. IT'S THE PITS
76. CLOSER! CLOSER! I SEE IT!!
77. MOON'S SONG: I GOT PLENTY OF NOTHIN'
78. LOST ON THE MOON
79. WHAT'S WHAT IN THE WAY OF SPACECRAFT
80. MODEL ROCKETS
81. ALTITUDE TRACKING OF MODEL ROCKETS

62

PILOT TESTS

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small or
Individual

TIME:

2-60 minute
periods

TYPE OF ACTIVITY:

Student Exploration

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Field of vision
Depth perception
Hand control
Physical tests

SKILLS:

Observation
Experimenting
Recording data
Constructing

RESOURCES:

40, 254, 258

Objectives: to experience some of the tests pilots and astronauts must pass; to become aware that physical fitness is important for a pilot.

Materials: (For Hand Steadiness Test) 1 - 1½ volt battery. 4 feet bell wire. 3-4 feet bare copper wire (10 or 12 gauge). 1 flashlight bulb and holder. 2 pieces 1" x 6" x 12" pine wood. 1 piece 1" x 4" for grip.

(For Field of Vision) 1 - 6" x 30" to 36" piece of tag board. Masking tape. Protractor.

(For Depth Perception) 1 - piece 1" x 8" x 18" pine board. 2 pieces 1' x 8" x 6" pine board. 1 piece ½ " x 1" x 2" pine board. 2 screw eyes (small). 2 - #6d box nails. 3 small nails or brads. 1 - 9' piece of string.

Teacher Background Information: To handle the special stress of near space and or space flight, a person must be in very good physical condition and pass special tests to qualify as a pilot of spacecraft or high speed jets.

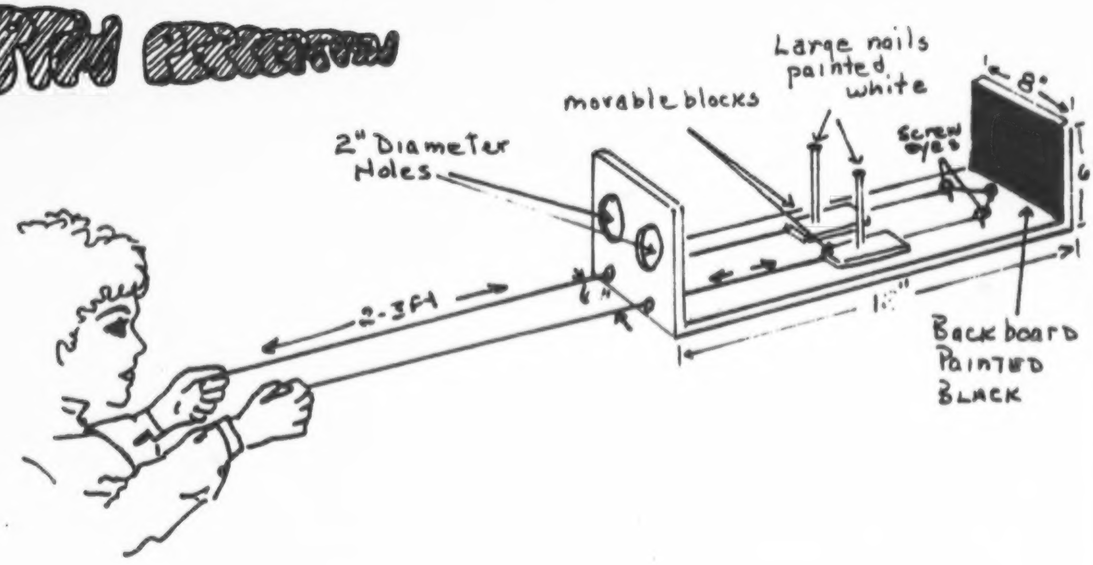
Other measurements and limitations give information to scientists who can prepare the spacecraft or plane to supply the pilot with whatever he or she needs for safety and efficiency.

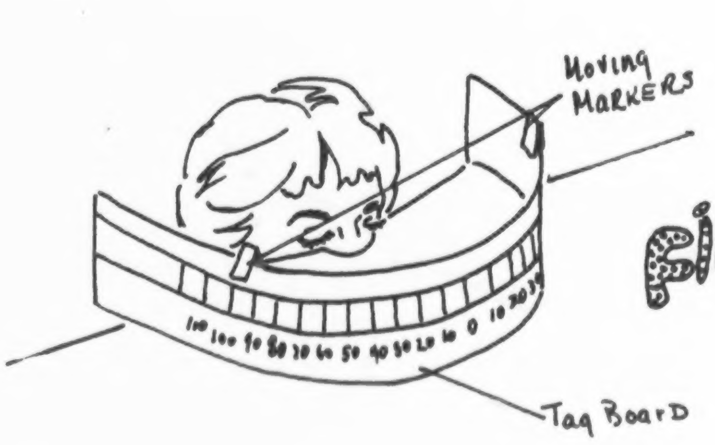
Procedure: Hand Steadiness Test. Construct the tester as shown. (See following page.) Try to pass the wand between the bare wire loop from one side to the other and back without causing the bulb to light.

Field of Vision Test. Construct the tester as shown. Move a marker or a pencil from the side toward the center. When the subject sees the marker out of the corner of his or her eye, record the angle on a graph. Repeat the process for the other eye. Make sure the person being tested looks directly ahead.

Depth Perception Test. Construct the device and have a student grasp the strings in each hand. While looking through the holes from 2 or 3 feet back, try to line up the nails side by side. Record any difference between the nails.

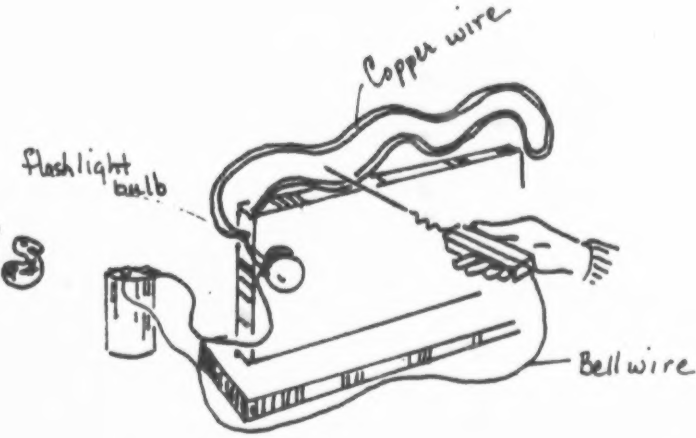
DEPTH PERCEPTION





FIELD OF VISION

HAND STEADINESS TEST



Youth in Aviation

ACADEMY OF MODEL AERONAUTICS

The AMA is a self-supporting, non-profit organization whose purpose is to promote development of model aviation as a recognized sport and a worthwhile recreational and educational activity open to anyone interested in model aircraft which fly. AMA sponsors a youth scholarship program. Awards are presented annually to deserving youngsters whose modeling skills match their scholastic abilities.

Model Aviation

Has grown over the years from an activity of mostly kids flying paper covered 'toy' airplanes, to a primarily adult activity involving sophisticated miniature aircraft with space-age construction and materials. It involves craftsmanship, aerodynamics and electronics.

For All Ages

Most participants are adults, including retired senior citizens, yet there are thousands of youngsters involved; such as 16-year-olds who fly in national and international competition and 8-year-olds (or less) who learn by building and flying balsa and tissue covered rubber powered models. Men, women, boys, and girls are all part of the scene.

An Educational Tool

The educational benefits of model aviation far exceed the obvious connections to aerodynamics and the manual arts. Science, chemistry and mathematics are involved, as well as weather, engineering and the laws of physics. They all play a part in the model aviator's aerospace education. Model aviation makes learning fun. As a deterrent to juvenile delinquency, aeromodeling is unsurpassed. No youth actively working on and flying model ariplanes has time to get into trouble. It's an activity which absorbs full attention and discourages distraction by other interests. An outstanding record of documentation attests to the character building and educational values of model building and flying.

Additional Services

AMA clubs provide flying sites, instruction and help to newcomers of all ages. There are 75 active AMA clubs in Michigan...find the one nearest...write for a membership application and the address of an AMA Chartered Club in your area.

For More Information

Academy of Model Aeronautics
815-15th Street N.W.
Washington, D.C. 20005
(202) 347-2751

4-H AEROSPACE PROGRAM

The 4-H program is the youth educational arm of the Cooperative Extension Service of the various state Land Grant Universities. It is an informal educational program designed to help youth from all segments of our society to grow into productive citizenship. The learning tool of these youth is the 4-H project. Projects vary from Beef Cattle to Clothing and from Woodworking to Aerospace. These programs in behalf of 4-H are made possible through the support of Business and Industry, Foundations, Government and individual cooperators.

Objectives

To create in youth an awareness of the basic concepts of space science and aeronautics. To develop in youth an interest and awareness of the impact of the aviation-aerospace program on society. To provide youth with the opportunity to develop skills and explore areas of interest in the aviation-aerospace program. Provide youth with the opportunity to explore various aviation-aerospace careers, and to provide experiences in aerospace science that will enhance the individual's responsible growth toward productive citizenship.

Purpose

The purpose of the program is to create an awareness in youth of the basic concepts of science and aviation, develop skills and to explore career areas, and provide experiences in aerospace science that will enhance the responsible growth of the individual and lead to productive citizenship. The development of a National 4-H Aerospace Program is presently an ongoing part of the program in 43 states and has reached the awareness level in all 50 states.

Program

The number of subject areas and activities in aerospace is unlimited. The leader and the members organize the program to meet their needs and interests. Starting points for the program represent five areas of youth interest—Rocketry, Aviation, Support and Utilization, Airport, and Aerospace Science. Each interest area can be divided into sub-areas and each can relate to other topics. Youth's minds provide the linkage. Some will find the manual, prepared especially for the five areas, fits their needs. Others will need to use other methods and materials. The self determined approach has been developed as an aid to this exciting process.

For More Information

State 4-H Office
175-South Anthony
Michigan State University
East Lansing, MI 48824
(517) 355-0180

63

HUMAN REACTION TIME

Objective: to relate reaction time to the rapid responses required during space flights

Materials: For Test 1-Reaction time card. (See following pages) Stop watch (or watch with second hand). Pencil. Test 2 - Duplicate of scale pasted over yardstick. (See following pages)

Teacher Background Information: Astronauts are ever aware of the possible occurrence of unusual situations during spaceflight. Pilots of near space and in space crafts know that the unexpected can happen and that they have to be ready to respond quickly. Unexpected problems may arise on a long space flight when crew members are likely to be more fatigued or complacent. These unexpected problems call for rapid responses using the senses of light, sound and feeling. The faster the reaction time of an astronaut, pilot or crew member, the better chance they will have to cope well with situations.

Procedure: Test I - Two students should work together, one to test his or her reaction time while the other times the responses.

1. Touch each square in the block in numerical order. Record the time.

Over 9 seconds	slow
9 seconds	about average
7 seconds	very good
5 seconds	excellent

2. Touch each square in reverse order. Record.
3. Touch each even square in order then each odd square in order. Record.
4. Try the other hand.
5. Graph your data after several trials. How do times compare? Make up some squares of your own to avoid "learning" the board.

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

20 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Reaction time
Stimulus/Response
Fatigue

SKILLS:

Recording data
Interpreting data
Using stopwatch

RESOURCES:

40, 298

HUMAN REACTION TIME (continued)

Test II - Duplicate the scale on the following page and paste it over a yardstick. The markings are in 1/100th of a second.

1. Rest a subject's right or left forearm on a table or desk top with hand extended over the edge. Drop the timing stick to pass vertically between the subject's index finger and thumb so that she may catch it after it starts to fall.

2. The beginning of the timer should be placed one inch lower than the top of the thumb. (Base line even with top of thumb.)

3. The length of time it takes for the subject to catch the stick can be read directly.

> How can you determine average reaction time?
> Does everyone have the same reaction time?

4. Blindfold the subject and have him or her catch the timer on a signal just as it is dropped. Is there a difference between visual and/or auditory cues?
If so, why?

Factors Affecting Human Time Lags

A. Reaction time varies with age:

Age	Sec.
5	0.40
10	0.30
20	0.20
30	0.22
40	0.25
50	0.28
55	0.35
60	0.50

B. Reaction time varies with practice. Reaction time can be reduced by practice approximately 10 percent.

C. Reaction time of left hand is 3 percent longer than right hand for right handed persons.

Human Reaction Time

for Test I

Time ____ seconds

5	7	1	2
9	8	11	6
12	10	3	4

Time ____ seconds

5	12	3	10
7	11	6	1
2	4	9	8

Time ____ seconds

.20
.19
.18
.17
.16
.15
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05
0
BASE LINE

for Test II

.29
.28
.27
.26
.25
.24
.23
.22
.21

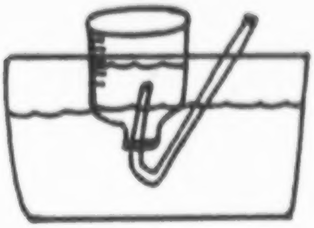
64

LUNG CAPACITY TEST

Objective: to make a physiological test which is an astronaut requirement for physical excellence.

Materials: A 5 gallon jug. 3' piece of flexible plastic tubing. Sink or large water container.

Procedure: 1. Place the jug in the sink, which should be half filled with water, with the open spout down and the tubing inserted as illustrated.



2. Have the subject suck on the tube, drawing the air out so that the water will rise to the top of the jug.

3. The subject then takes a deep breath and, placing his lips on the tube, blows as hard as possible in order to blow out as much of the water as s/he can.

4. Measure the amount of water displaced by using the formula

$$\pi R^2 h$$

This will give you a rough number of the cubic inches of lung capacity the subject has.

5. After you have measured the student's lung capacity, discuss the necessity of good health for pilots. How is lung capacity an indication of good health? How can students build their lung capacity? What about smoking?

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

15 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Lung Capacity
Displacement

SKILLS:

Observation
Recording data
Using formulas
Measuring

RESOURCES:
40, 298

65

GETTING THERE

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Individual and Small group

TIME:
30 minutes

TYPE OF ACTIVITY:
Discussion and Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Gravitational attraction
Escape Velocity

SKILLS:
Observation
Inference

RESOURCES:
191, 192, 196, 199, 202, 259

Objective: to explain why powerful rocket engines are needed to achieve orbit and overcome the Earth's gravitational field.

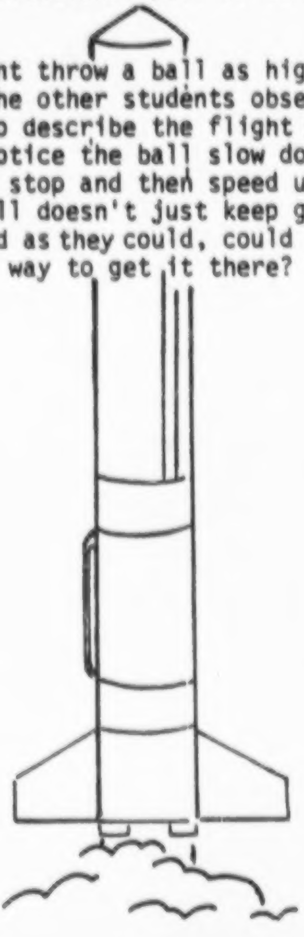
Material: Baseball.

Teacher Background Information: If you could throw a ball hard enough, theoretically, you could throw it to the moon. Gravity however, pulls it back. You would have to throw the ball about 40,000 Km/h (Escape Velocity) to overcome gravity. A fast ball thrown by a major league pitcher may reach 200 Km/h. A bullet leaves the barrel of a gun at about 2,000 Km/h, only one tenth as fast as a rocket needs to go to leave the Earth's gravitational field.

As the object leaving the earth gets farther away, the pull of gravity gets less and less. Likewise, as an object gets closer to a planet or moon, the stronger and stronger becomes the gravitational pull of that planet or moon.

Procedure: Have a student throw a ball as high and straight up, as possible. Have the other students observe the flight of the ball. Ask them to describe the flight path in a very precise way. Did they notice the ball slow down as it got higher? Did they see it stop and then speed up as it fell?

Ask them why the ball doesn't just keep going. If they threw a ball as hard as they could, could they get it to the moon? Is there a way to get it there?



CONSTRUCTING AN ACTION-REACTION ENGINE

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Large

TIME:
30 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Action-reaction
Propulsion

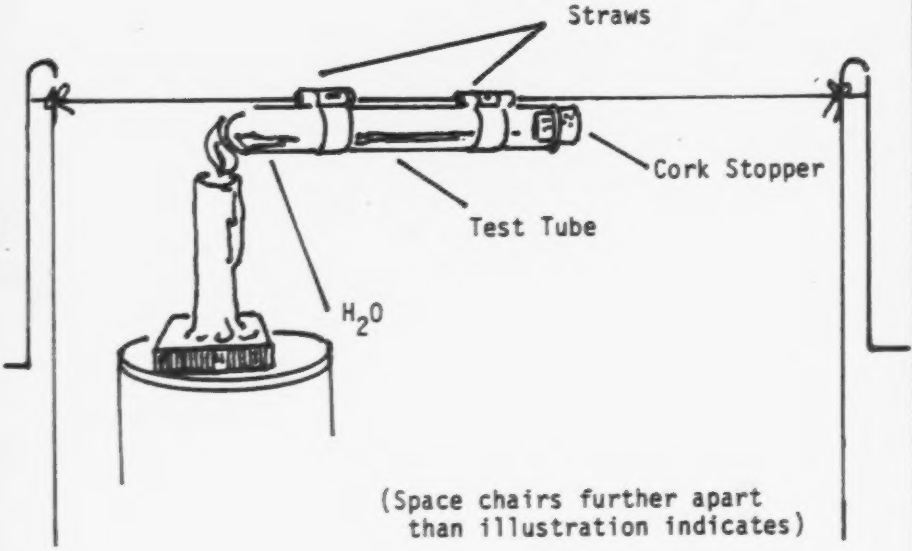
SKILLS:
Observation
Inference

RESOURCES:
40, 298

Objective: to illustrate Newton's Third Law of Motion; To demonstrate the similarity between this experiment and the propulsion system used on a rocket engine.

Materials: Small test tube with cork (Pyrex test tube from science lab.) Water. Candle. Thread. 2 chairs. Tape.

Procedure: Set up apparatus as illustrated.



(Space chairs further apart than illustration indicates)

Lubricate cork stopper with Vaseline.
Place a tablespoon of water in the bottle. Position test tube over candle flame and note the reaction of the test tube as the cork pops out.

How does this investigation illustrate Newton's Third Law? How is this similar to a rocket engine?

67

BREAKING AWAY

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Large

TIME:

20 minutes

TYPE OF ACTIVITY:

Demonstration

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Escape Velocity
Gravity

SKILLS:

Observation
Inference
Drawing conclusions

RESOURCES:

153, 163, 267, 285, 287, 298

Objective: to demonstrate the effects of reaching escape velocity and overcoming gravitational pull.

Materials: String. Rubber stopper. Scissors.

Teacher Background Information: When a space craft reaches 18,000 miles an hour, it can achieve orbit around the earth. Eventually, however, gravity will pull the space craft back to earth. If the space craft is speeded up to about 25,000 miles an hour, the force of gravity is offset and the craft can leave orbit.

Newton's 1st Law of Motion states that a thing set in motion will travel in a straight line and continue traveling in the path until acted upon by another force. Newton's 2nd Law of Motion says that something at rest will stay at rest until acted upon by a force. As soon as a space craft overcomes gravity, it will start off in a straight line until acted upon by changing its speed or direction with manuevering rockets or when "captured" by another gravitational force.

Procedure: Have a student tie a rubber stopper to a string and spin it in a vertical loop. When the stopper is at the top of a loop, cut the string or let go of the string. (Make sure this is done in a safe place, perhaps outdoors).

Ask student to tell you what they observe when the string is cut. Have the students describe what path the stopper takes. At what point does it change direction? How is the string like gravity? If the student twirled the stopper and the stopper represented Earth, what would the student represent? If the stopper were the moon, what would the Student be? What force acting on a space craft must be removed to let it fly away from earth?

ON STAGE FOR ORBIT

68

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Large

TIME:

30 Minutes

TYPE OF ACTIVITY:

Demonstration or Small group investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Orbit
Thrust
Gravity

SKILLS:

Experimentation
Observation
Inference
Drawing conclusions

RESOURCES:

192, 224, 256, 273

Objectives: to understand how a satellite can stay in orbit around the earth; to discover why it takes a two stage rocket to put a satellite into orbit.

Materials: 1 inflated rubber basketball. 1 foot of clothes hanger wire. 18" piece of string. 1 plastic pen cap. 1 one ounce lead sinker.

Procedure: Before the investigation, ask the students why they think it is necessary to use a vehicle with two or more rocket engines. Ask what some of the things are that affect the size and shape of an orbit. What are some of the things that may affect the period of time a satellite will remain in orbit?

After discussion, set up the investigation by, first, filing one end of the wire to a point. Then, insert other end into basketball air hole. Tie one end of the string to the pen cap and the other end to the sinker. Place the cap on pointed end of wire. (See illustration.)

1. Once this is done, push the sinker up and away from the surface of the ball with a slight tap. The sinker moves up and then falls right back to the starting point. Relate this to a single engine projecting a rocket away from the earth.

2. Now push the sinker away from the ball at an angle so that it swings part way around the ball. What does the distance spanned depend on? (Angle and forcefulness of the tap.)

3. With a stronger tap, push the sinker off the surface at an angle so that it spins around the ball a couple of times.

This is an example of a one stage rocket. Ask how this is so. (A one stage rocket launched directly from the earth must return to earth in the same way.) Ask how that might be changed.

4. With one tap (first stage), push the sinker straight

up from the surface of the ball. With another tap (second stage), push the sinker in a direction parallel to the surface. (See illustration on next page.)

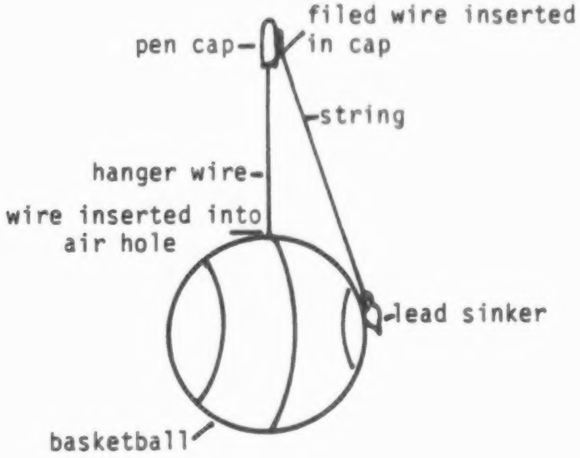
The sinker is now in orbit around the basketball. Ask how the two taps are related to staging.

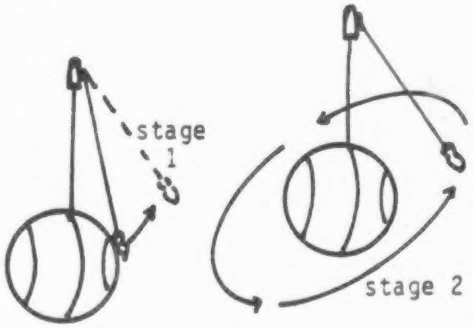
What does the first tap do? (Gets sinker away from ball - rocket away from Earth.)

What does the second tap do? (Puts sinker in orbit - rocket in orbit.)

How long will the rocket/sinker stay in orbit? (Until gravity pulls it back.)

Note: You may use the activity sheet on the next page to set up a small group investigation which the students do completely on their own, or simply use the activity sheet as you do the demonstration of the experiment with them.





Satellites in Orbit

ACTIVITY

1.
Push the sinker up and away from the surface of the ball with a slight tap. Describe your observations.

2.
Push the sinker away from the ball at an angle so that it swings part way around the ball. What does the distance spanned depend on?

3.
With a stronger tap, push the sinker off the surface at an angle so that it spins around the ball a couple of times. How is this like a one stage rocket?

4.
How could you change the direction of the rocket?

5.
If you haven't already thought of this solution, try the following: With one tap, push the sinker straight up from the surface of the ball. With another tap, push the sinker in a direction parallel to the surface. What happens?.

6.
How does this experiment illustrate staging of rockets?

7.
What force must be constantly overcome in order to put and keep rockets in orbit?

69

HITTING THE MOON

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Small

TIME:
25 minutes

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Revolution
Rotation
Leading a moving target
Relative motion

SKILLS:
Observation
Inference
Hypothesizing

RESOURCES:
150, 163, 282, 291, 298

Objective: to show students that a rocket must be aimed in front of the moon in order to arrive at the place where the moon will have moved while the rocket traveled from the Earth to the Moon's orbit.

Materials: Soft balls (Nurf or Tennis). Waste basket.

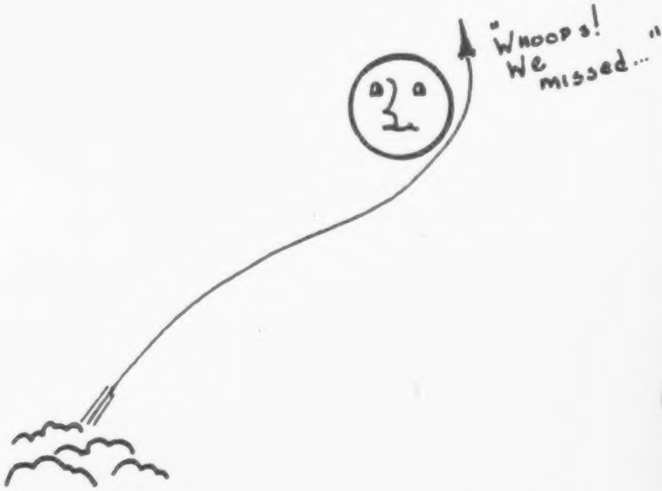
Procedure: 1. Have a student stand still and shoot a ball into a waste basket from about 2 meters away. The student probably won't miss.

2. Have the student turn slowly around where she/he is and then try to hit the basket while still turning. A little harder, perhaps.

3. Now have another student hold the basket and move around the ball thrower in the same direction he/she is turning but much slower. Now have the student try to hit the basket. How do the two motions affect hitting the basket? Try it with the basket carrier 3 meters away or 4 meters away.

4. Discuss what the thrower must do to hit the basket while it and s/he are moving. Relate to what a quarterback must do sometimes. Then relate this to the way a space craft must be aimed in order to hit the Moon.

5. Try hitting the basket with a much smaller ball. Is it easier? More difficult? Why do the students think this happens? A space craft is very tiny compared to the moon. Discuss the added difficulty. Discuss the idea that both speed and size need to be factored in to a problem like this.


"Whoops! We missed..."

70

HOT UNDER THE COLLAR

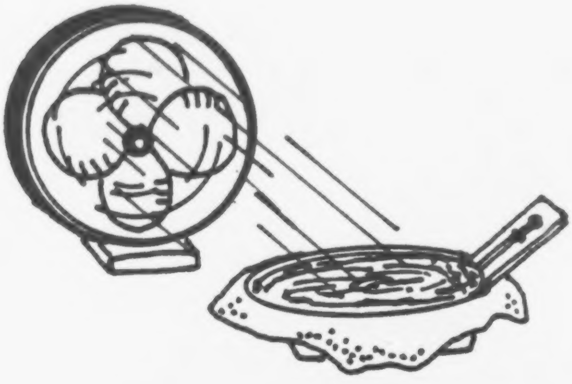
Objective: to experience heat loss due to evaporation; to understand the process used to remove heat from space suits.

Materials: Alcohol. Water (room temperature). Small card. Fan. Pie plate. Wash cloth. Thermometer.

Teacher Background Information: The human body can only operate within a small range of temperatures. Pilots who must wear airtight "g" suits or space suits can become very uncomfortable within a short time. Circulating dry air throughout the inside of the suits removes the moisture and cools the pilot's body.

Procedure: Activity 1 - Place a few drops of water or alcohol on the back of your hand. Aid evaporation of the drops by fanning them with a small card. Note the change in temperature.

Activity 2 - Why moving air in the astronaut's suit cools him but does not cool the suit or the capsule, can be shown in the following: Hold the thermometer in the breeze of the fan and note the reading. Place it in the water and let the fan blow on the water. Read the thermometer again. Place the washcloth in the pan, draping it over the sides, as shown, and note the change in temperature of the water. The moving air helps to evaporate the water out of the pan in the same way that the circulating dry air in the space suit removes perspiration from the body of the astronaut.



SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

20 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Expository

CONCEPTS:

Evaporation
Energy transfer
Heat exchange

SKILLS:

Observing
Collecting data
Inference

RESOURCES:

213, 265, 296

71

MANUFACTURING WATER IN SPACE

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Large or Small

TIME:

45-60 minutes

TYPE OF ACTIVITY:

Demonstration or
Student Experiment

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Molecules
Atoms
Electrolysis

SKILLS:

Experimenting
Observation
Inference
Drawing Conclusion

RESOURCES:

210, 253, 260, 261, 276

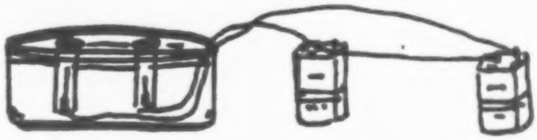
Objective: to see that water (H_2O) is made up of two gases, Hydrogen and Oxygen.

Materials: 2-6 volt lantern batteries. 2-2 foot pieces of bell wire. 2-1½" long pencil leads. 1 large jar. 2 small vials or test tubes. 15 ml of Epson Salts (3-4 tablespoons). Water. Electrician's tape.

Teacher Background Information: Water is a basic need of human beings in order to live more than a few days. Unfortunately it weighs a bit more than 8 pounds per gallon. This makes it difficult to take into space when much is needed. Another need in a space capsule is electricity to run many of the instruments and the radios. Special fuel cells manufacture electricity by combining Oxygen (O_2) and Hydrogen (H), a process which releases a little energy and also makes water.

Procedure: You can separate water into Oxygen and Hydrogen by passing an electric current through it.

1. Wrap the bare ends of two pieces of wire around the ends of two pencil leads. Cover the lead where the wire is attached with electrician's tape. Leave the rest of the lead exposed.
2. Mix about 15 ml of Epson salts in a liter of water. Stir until all the Epson salts are dissolved.
3. Fill two small vials with water and place them upside down in the jar of solution. Keep the vials covered as you immerse them so no air gets in.
4. Carefully place the vials over the pencil leads and connect the other end of the wires to two 6 volt batteries wired in series. (See diagram).
5. You should see bubbles of gas in each of the vials.
6. Test the gas with a glowing splint. If the splint burst back into flame, the gas is Oxygen. Ask the students why they think that happens. If the gas makes a little "pop" sound, it is Hydrogen. (Be sure to keep the vials upside down when you take them out of the water. Cover the mouth of the vial until you are ready to test with the splint)
7. One vial will get about twice as much gas as the other. From the formula (H_2O), can you think why this may be so?



72

GETTING DOWN IN EGGSACTLY ONE PIECE

Objective: to explore methods of landing delicate cargo when there is little or no atmosphere to slow vehicle down.

Materials: Raw Eggs. Various student gathered materials.

Teacher Background Information: Landing a space vehicle on the moon or any planet with a thin atmosphere is a problem unlike landing on the earth. Parachutes are ruled out because no air is available to operate one.

Procedure: Talk with students about landing safely on a planet without air. Explain they have a problem to solve and they have X amount of time to do it in. They must then prove that their solution works. They are to get a raw egg safely to the ground from a height of at least 30 feet, (off the school roof, over a bannister from the second floor, etc.), without parachutes and in something smaller than a shoe box. Cracked or broken eggs will be considered evidence of the need for further experimentation.

Give them a few days to design and construct a solution and arrange for the test site.

On the test day, gather the eggs (!), your students and have each one drop their landing device. Retrieve each one and check the condition of the egg.

After the experiment, discuss what sort of devices, constructions and materials seemed to work best. Ask how those students went about working out their solutions and planning for the test. Relate again to setting people and spacecraft down on other planets without enough air for resistance and see if some of the solutions used for their eggs might relate to that problem.

Extension: Have students research how NASA and other aerospace agencies have worked out the problem of landing delicate cargo on other planets.

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Individual

TIME:

10 minutes to introduce/
60 to test

TYPE OF ACTIVITY:

Student Investigation
and invention

CONCEPTS:

Shock absorbtion
Resistance
Impact
Deceleration
Acceleration

SKILLS:

Inventing
Hypothesizing
Experimenting
Measuring

RESOURCES:
241, 261, 280, 283, 294

73

NEUTRAL BUOYANCY

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Large

TIME:

20 minutes

TYPE OF ACTIVITY:

Demonstration

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Neutral buoyancy
Water pressure
Float & sink

SKILLS:

Observing
Inference

RESOURCES:

279, 290

Objective: to simulate a weightless condition on Earth by neutral buoyancy.

Materials: Long glass cylinder container. Miniature glass tube. Water.

Procedure: Fill larger container with water. Add water to smaller tube and invert it inside the larger container. The small tube should have enough water inside it so that it will float even with the top of the larger container. Make sure water is even with the rim of the large container. Place palm of hand over larger container to form a seal (could use a cardboard or rubber as a sealer). Apply pressure with palm and the small container will sink inside the larger one. By regulating the pressure of the palm of the hand you determine the depth of the smaller container.

Relate the demonstration to fluid pressure and discuss the demonstration as an illustration of a condition under which astronauts sometime train such as in sea labs and neutral buoyancy tanks.

Extension: Astronauts also experience weightlessness during training in planes which fly a parabolic arc course in the sky. Have the students research this and report what actually happens. The same feeling occurs in a car as you drive over a hill which drops sharply away or in a roller coaster as you crest over the top.

74

REDUCING YOUR WEIGHT (ON THE MOON)

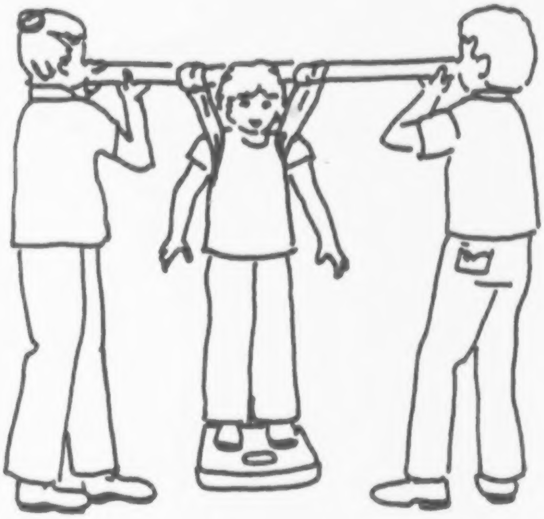
Objective: to develop an appreciation of the relationship between Earth gravity and that of the Moon and Mars.

Materials: 4' bar or large dowel rod. Old bicycle tube. Bathroom scale.

Teacher Background Information: Astronauts experience weightless conditions in space and greatly reduced gravity on the Moon. Moon gravity is about 1/6 that of Earth. Mars has about 4/10 the gravity of the Earth. There are a number of biological effects of weightlessness on astronauts. Have the students research some of these.

Procedure: Make the apparatus as shown in the sketch. The apparatus can be used to simulate weight on other planets. "Zero gravity" can be felt in a child's feet by lifting them just a little. With a bit of research, children can find out how much they weigh on other planets and the Moon.

Have students figure their Moon weight (1/6 their Earth weight) and their weight on Mars (4/10 what they weigh on Earth). Record the Name, Earth weight, Mars weight and Moon weights. Have two students lift one student up enough to register their Moon weight and Mars weight on the bathroom scale. This will give them some feeling of what it feels like to be in reduced gravity.



SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

40 minutes

TYPE OF ACTIVITY:

Demonstration
Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Zero Gravity
Reduced Gravity

SKILLS:

Observation
Collecting data
Modeling
Measuring

RESOURCES:

250

75

IT'S THE PITS

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

45 minutes

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Crater
Impact
Meteoroid

SKILLS:

Experimentation
Observation
Hypothesizing
Drawing Conclusions

RESOURCES:

136, 257, 267, 275, 277, 291

Objective: to develop a model for the formation of craters.

Materials: (per team) 1 shallow pan. 1 sheet of newspaper. 1 small steel ball. 1 marble. 1 meter of thread. Tape. Enough sand to fill pan about 1" deep. Light Source. Ranger images (following pages).

Procedure: Lay the sheet of newspaper on the floor. Place the pan in the center of the paper. Pour sand into the pan to a depth of about 1 inch. (3 cm) Smooth the sand out but do not pack the sand down or shake the pan. Attach the thread to the steel ball with a small piece of tape. Hold the ball about 20 inches (50 cm) above the pan. Leave slack in the string so that the ball does not jerk back when dropped.

Drop the ball into the sand. Gently lift the ball straight up out of the sand. Examine the crater that was formed. Illuminate the crater from the side with a flood light or a bare bulb. Compare what you see with the Ranger images provided. Can you infer which direction the sun is coming from in the pictures of the moon?

Measure your crater. Record data.

Now drop the glass marble in the same way you did the steel ball from 50 cm. How are the craters different? How are they the same? Measure and record data.

Try the balls one at a time from 1 meter (about 3 ft.) How are the craters different now? Can you conclude what makes a difference in the size of moon craters?

Extensions: Research characteristics of moon rocks. ** Obtain samples of moon rocks from NASA. Compare rocks found on earth with moon rocks.

**Contact NASA for information on how to go about obtaining moon rocks for your classroom.

Education Coordinator
Mail Stop 8-1
Visitor Information Center
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

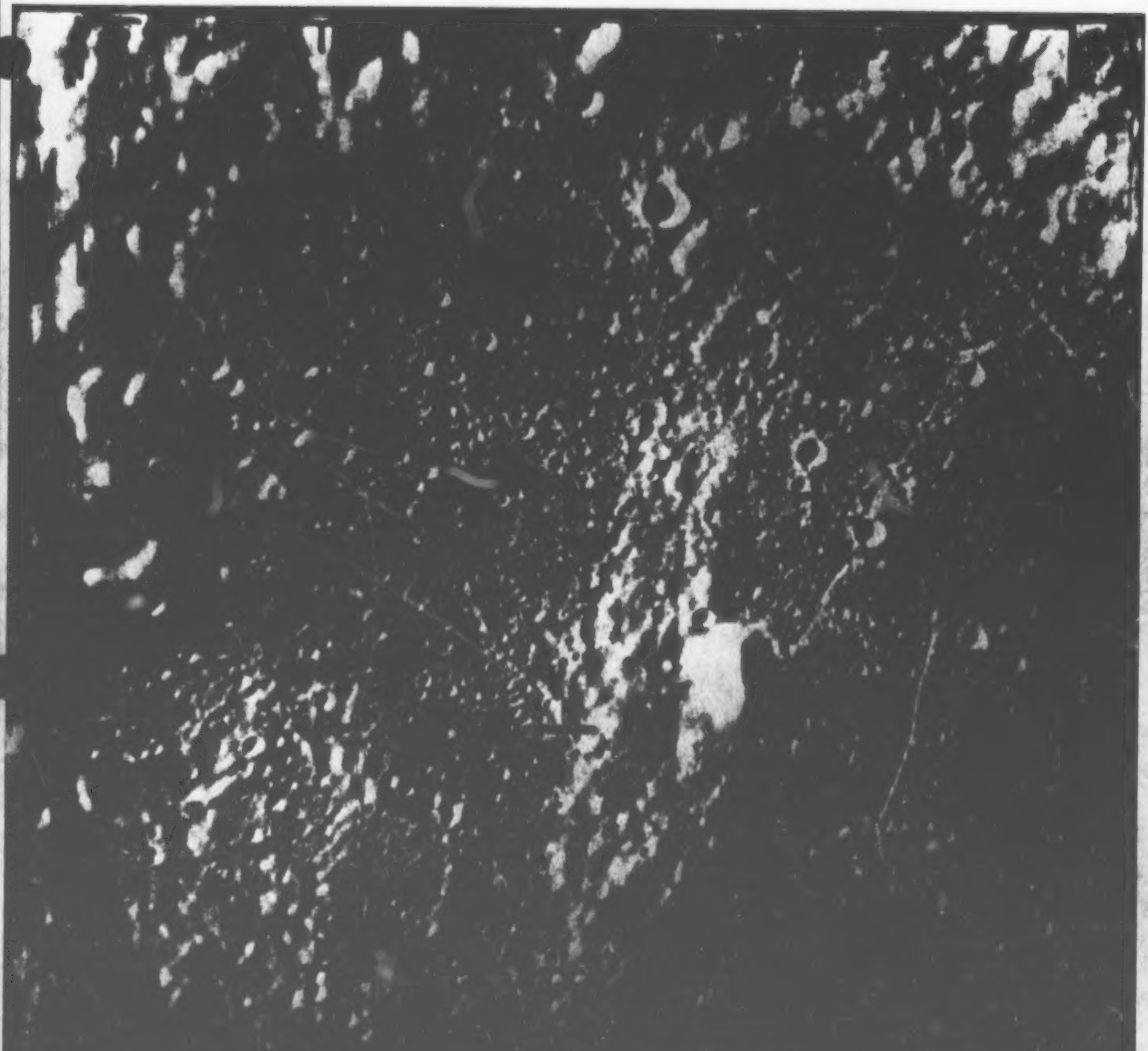


PLATE D (RANGER IX IMAGE)

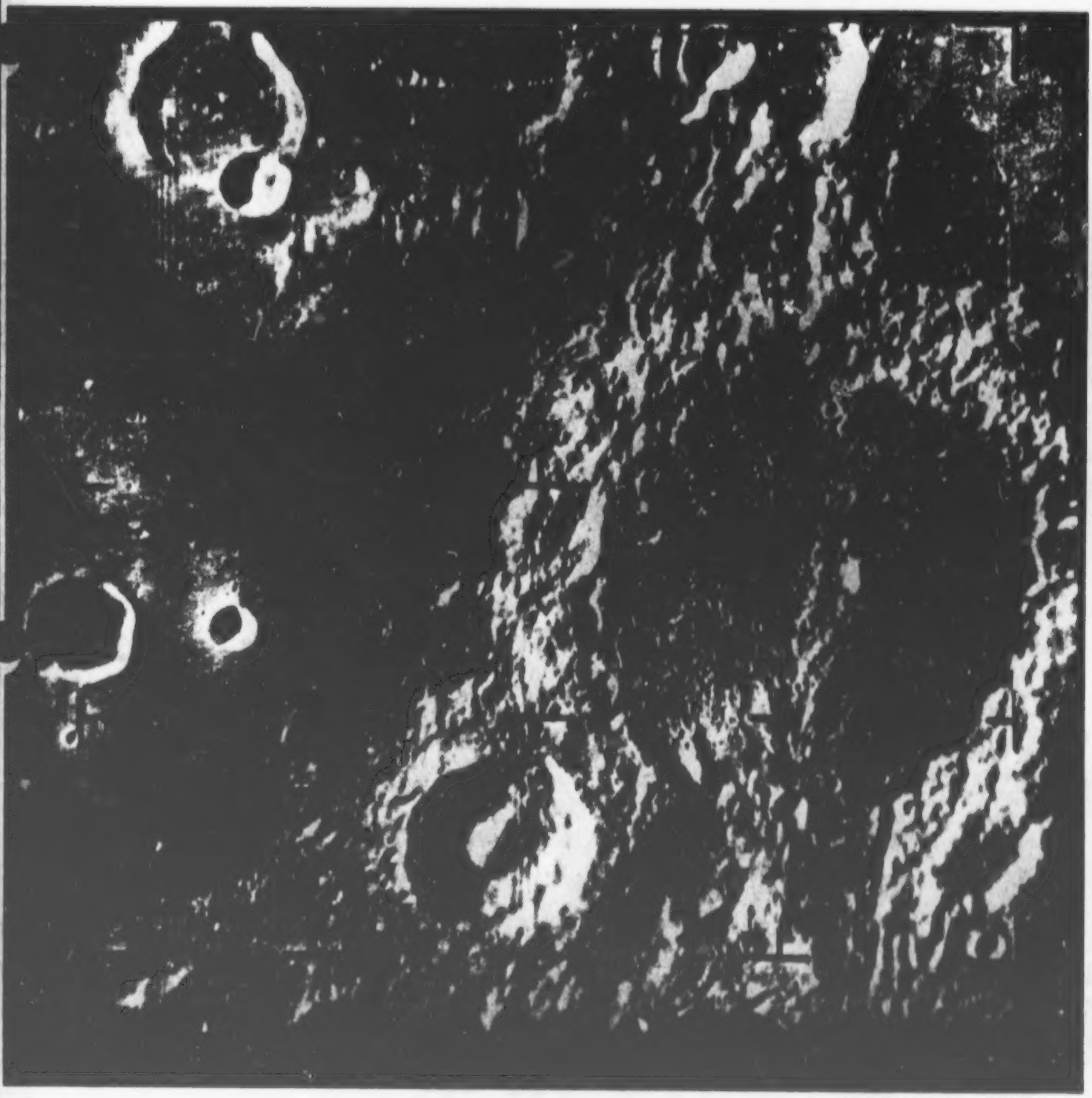


PLATE G (RANGER IX IMAGE)

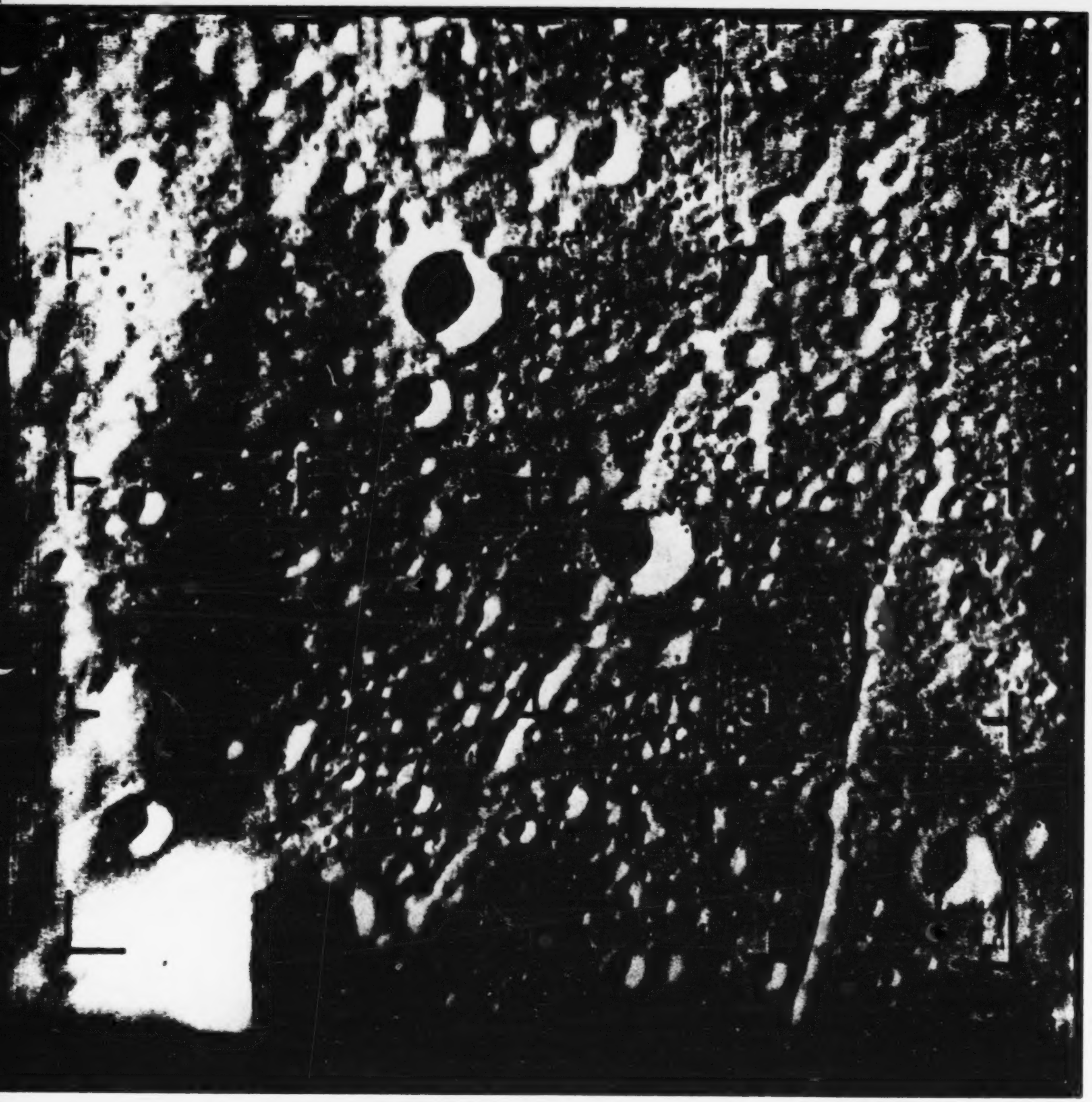


PLATE H (RANGER IX IMAGE)

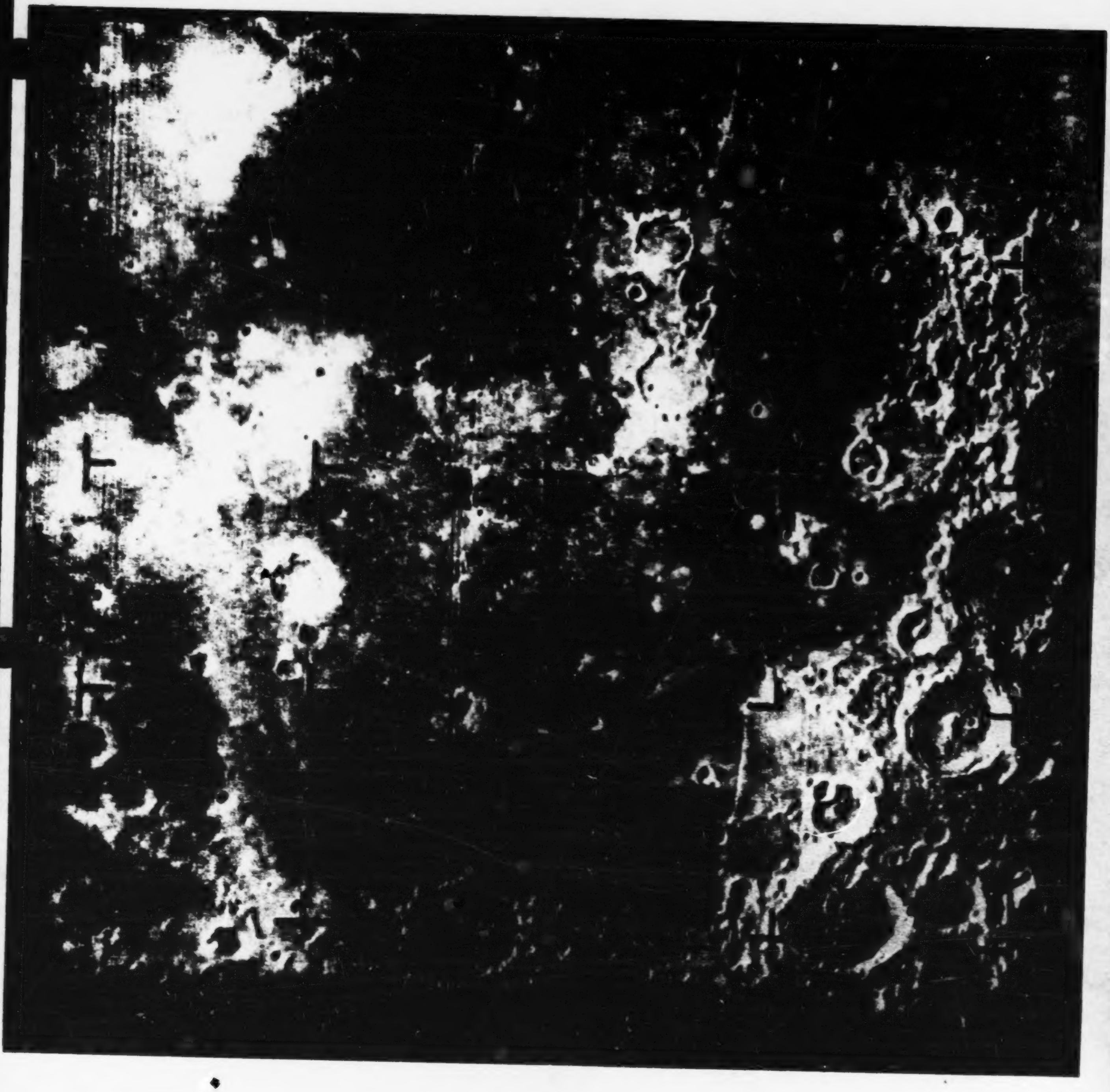


PLATE K (RANGER IX IMAGE)

183

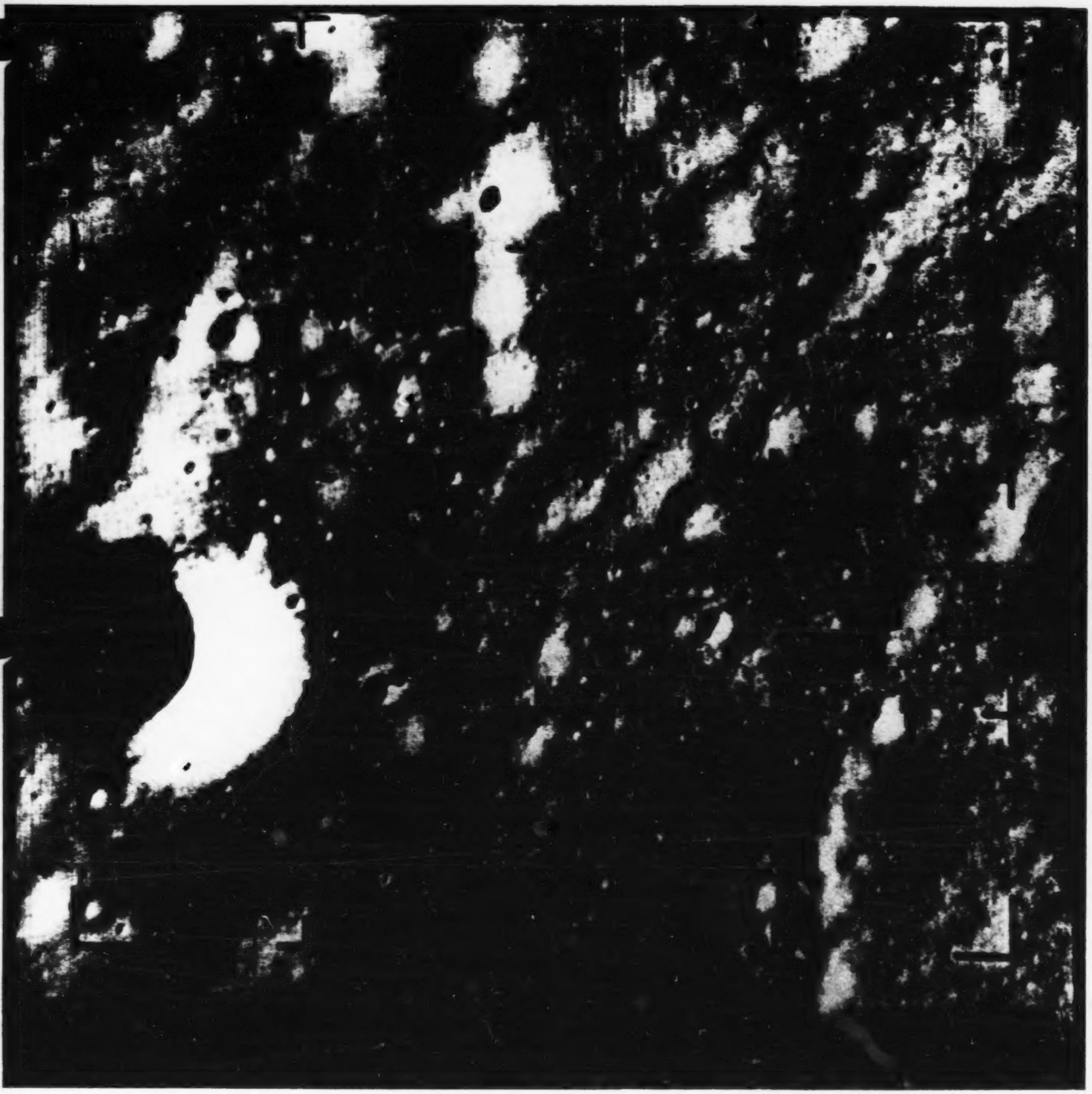


PLATE L (RANGER IX IMAGE)

76

CLOSER! CLOSER! I SEE IT!!

Objective: To develop greater understanding of the need to investigate "close up."

Materials: Ranger IX images of the Moon. (See preceeding pages). Pictures of teacher's choice.

Procedure: In order to show students how important it is to really see details in order to better know something, stand in front of the classroom with a picture of something that can be discerned but has greater detail as one comes in closer to it. Saturn is super. The students can see it is a planet - with a ring - from pretty far back but, as they get closer, they can see there are many rings and inside them are many moons. A number of pictures of everyday scenes will make the same point.

Talk about what it means to scientists, and to all of us in everyday circumstances, to know as many of the details as possible before we can make any meaningful generalizations about a thing. How can we discover those details? (Better telescopes. Go there. Send robots. Bigger samples, etc.) Brainstorm ways and talk about them.

After the discussion, have students look at the Ranger IX images. Ask what they have in common. How are they different? What do they think they might be of? Let them discover that they can be ordered and are images of the same thing from shorter and shorter distances. (Plate K-G-D-H-L) What can they see in Plate L that they could not see in K? Discuss, again, the importance of detail in order to "know."

Extension: 1.) This is a good lead in to the importance of details to all "knowing." What are the details involved in a complex math problem and how do the details help us know what the problem really means?

How do we "know" another person? A character in a book? A piece of art? A piece of music?

How do we know our town or state or country? What sort of details must we look for and how do we do that? HOW DO WE GET CLOSE UP? As you and your students engage in other kinds of learning, use that question a lot!

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Large

TIME:
30 - 40 minutes

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Detail
Moon's surface

SKILLS:
Observation
Inference
Generalization

RESOURCES:
141, 228, 233, 257, 267, 291

77

MOON'S SONG: I GOT PLENTY OF NOTHIN'

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Small

TIME:
2-50 minute periods
+ search time

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Lunar environment
Hostile environment

SKILLS:
Data Collecting
Reporting
Comparing

RESOURCES:
141, 228, 257,
267, 291

Objectives: To describe some of the characteristics of the moon's environment; to compare the moon's hostile environment to Earth's environment.

Materials: Reference material - books, pamphlets, magazines, encyclopedias. Lunar word puzzle worksheet.

Procedure: Cut out the individual word puzzles and distribute one to each group. Explain that the students are to figure out what aspect of the moon's environment they are to research by unscrambling the letters on their paper. Give them a bit of time to do that and to organize their search. Allow a few days to find the information.

When they have finished, have each group present what they have learned to the class at large. Encourage pictures, drawings and illustrations as support for what they found. Encourage questions and have students write down questions that require further investigation. Work out ways of finding those answers.

After the moon's environment has been discussed and the remaining questions have been looked into, do a comparison of the Earth's environment to the Moon's. Ask students to note similarities and differences in their notebooks as you discuss them and write them on the board.

Extension: There's an activity coming up called, "Lost on the Moon." This is a very good activity to use as a lead in; in fact, it's really only fair that the students have some background on the moon's environment before they do "Lost on the Moon."

Key: 1.) Craters 2.) Moon Rocks 3.) Temperature
4.) Weather 5.) Lunar Life 6.) Communication
7.) Gravity 8.) Atmosphere 9.) Moonquakes
10.) Mountains

LUNAR SCRAMBLE...

TRAESCR....How did they form? What are they like?

OMNO CRKOS....What do they tell us? Where can earthlings get some?

RRAPEMTEUET....What's the highest? Lowest? How do the astronauts manage?

THWEERA....Is there any? How does it affect what goes on there?

ULRAN IFLE?....Is the moon a dead duck? Do we know for sure?

UMCACOMTNINIO....Why can't you hear when you're called? How is it done?

YVARGTI....How does it compare to Earth's? What are the problems? Advantages?

MSHRPEETAO....What is it like? Why is it hard to land? Breathe?

OOQMNAKSEU....How do they happen?

TINOUNSMA....How were they formed? Are they like the ones on Earth?

78

LOST ON THE MOON

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Small

TIME:
60 minutes

TYPE OF ACTIVITY:
Game

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Survival
Group concensus

SKILLS:
Decision making
Hypothesizing
Inference

RESOURCES:
163, 180, 243,
245, 255, 267

Objective: To use knowledge of moon's environment to make logical choices about equipment available for survival; to practice group concensus skills.

Materials: Copy of "Lost on the Moon Survival Items" (1 for each student). Pencils.

Procedure: 1. Distribute copies of the worksheet and have students individually rank the items, given the information at the top of the page. (about 10 minutes)

2. Divide class into workable groups.

3. Explain that this is an exercise in group decision making. Each group is to use the method of group concensus in reaching its decision. This means that the prediction for each of the 15 survival items must be agreed upon by each group member before it becomes a part of the group decision. Concensus is difficult to reach, therefore, not every ranking will meet with everyone's approval. Encourage the students to listen to each other and to find out why someone feels an item should have a particular ranking before the decision is made by the group. Avoid voting; it generally leads to trouble.

4. Give the students 20 minutes to make their group decisions.

5. In large group, read NASA's ranking to the students and have them compare their choices with NASA's. Take the time to go over why the item was ranked the way it was by NASA. When the ranking is done, have students work out their scores.

"LOST ON THE MOON SURVIVAL ITEMS"

DIRECTIONS: Your spaceship has just crash-landed on the dark side of the moon. You were scheduled to rendevous with your mother ship 200 miles away on the lighted surface of the moon, but the rough landing has ruined your ship and destroyed all the equipment on board, except for the 15 items listed below.

Your crew's survival depends on reaching the mother ship, so you must choose the most critical items available for the 200-mile trip. Your task is to rank the 15 items in terms of their importance to your survival.

ITEMS	NASA's Ranking	Your Ranking *	Error Points	Group Ranking **	Error Points
Box of Matches					
Food Concentrate					
Fifty feet of nylon rope					
Parachute silk					
Solar-powered portable heating unit					
Two 45 caliber pistols					
One case of Pet milk					
Stellar map (of the moon's constellation)					
Two 100 pound tanks of oxygen					
Self-inflating life raft					
Magnetic compass					
Five gallons of water					
Signal flares					
First aid kit containing injection needles					
Solar-powered FM receiver/transmitter					
TOTALS					

Error points are the difference between your ranking or the group's ranking and NASA'S.

KEY TO LOST ON THE MOON

NASA'S RANKING	NASA'S REASONS
15	No oxygen to sustain the flame
4	Good food energy source, efficient
6	Useful in scaling cliffs, tying together the injured
8	Will provide protection from sun's rays
13	Useless on dark side; not needed on lighted side
11	Possible means of propulsion
12	Bulky duplication of food concentrate
3	Primary means of navigation
1	Most pressing need
9	CO_2 bottle in raft may be used for propulsion
14	Magnetic field on moon is not polarized, worthless
2	Replacement for high water loss on light side
10	Distress signal when mother ship sighted
7	For injecting vitamins - special aperture in suit
5	Talk to mother ship, FM needs short range and line of sight

79

WHAT'S WHAT IN THE WAY OF SPACECRAFT

Objective: To use research to learn about spacecraft and associated hardware significant in the history of space exploration.

Materials: Various research materials from NASA on specific spacecraft. Pictures of spacecraft.

Procedure: Put the name of each space craft on a separate piece of paper. Have the students split up into small groups and choose a slip of paper from a hat.

The students should then research the history and purpose of the craft they picked. Ask them to consider the information gathered by the spacecraft as it went about exploring space.

How has what was learned from each craft affected us on earth? What benefits have been gained from the exploration? How has the knowledge changed our concept of earth and space?

Have the students make presentations to their class about what they found. Encourage pictures, drawings, models and illustrations of the craft and related information. When they are all finished, display the information and visuals in a spacecraft display.

Extension: Have the NASA space mobile visit your school. Request additional information be provided about the spacecraft which were researched.

For information on how to arrange the visit, write or call NASA:

Education Coordinator
Mail Stop 8-1
Visitor Information Center
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
(216) 433-4000, Ext. 6110 or 731

NASA Spacecraft:

- Apollo
- Gemini
- Mercury
- Explorer
- Surveyor
- Pioneer
- Viking
- Voyager
- Eagle
- Columbia

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

Several days

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Satellites
Exploration

SKILLS:

Gathering and interpreting data
Researching
Using references
Reporting

RESOURCES:

189, 205, 208, 233, 236, 252, 253, 265, 277

80

MODEL ROCKETS

SUBJECT:

Science

GRADE:

Fifth

GROUP SIZE:

Small

TIME:

Several days

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Action-Reaction
Thrust/Drag
Launch
Altitude
Gravity

SKILLS:

Modeling
Experimenting
Collecting data
Comparing

RESOURCES:

183, 188, 194, 197

Objective: To study, assemble and launch a model rocket; to learn model rocket safety procedures; to set up a launch and rocket recovery area.

Materials: Model Rocket Kits including rocket engines and igniters. Launch equipment. Model Rocket Activity Guides available from Estes Industries.

Procedure: Obtain model rocket guides and technical manuals from a reputable supplier or manufacturer. Estes has a 4 week guide and is an excellent source. Bob Cannon is the Education Director at Estes.

If you are familiar with concepts related to model rockets, you may wish to have:

1. a demonstration launch
2. students build model rockets
3. students study safety procedures
4. students set up a launch area
5. students launch the class rockets
6. students gather data about altitude, reliability of ignition, flight characteristics, accuracy of landing, etc.
7. students compare thrusts of different engines
8. students make graphs of data.

Source:

Education Department
Estes Industries
Department 161
P. O. Box 227
Penrose, Colorado 81240

81

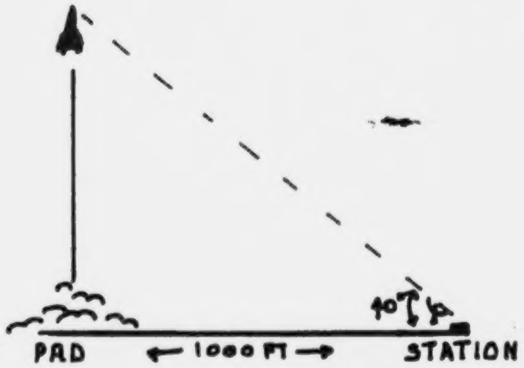
ALTITUDE TRACKING OF MODEL ROCKETS

Objective: To practice measuring and plotting similar triangles on a graph in order to determine the altitude of a model rocket or other object.

Materials:
Protractor.
Straw. Weight. or altiscope
Tape. String. or hypsometer

Graph paper. Pencil

Procedure: Have a student measure off 500 to 1000 feet from the rocket launch pad. This point is the "sighting station." Using a sighting device, measure the angle to the peak altitude the rocket reaches.



Method I. Locate the tangent of the angle read on a table of tangents. Multiply the tangent times the distance from the rocket launch pad to the "sighting station." The resulting figure is the altitude of the rocket flight.

TABLE OF TANGENTS

Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

Estes Rockets, Penrose, California

(con't)

SUBJECT:
Science

GRADE:
Fifth

GROUP SIZE:
Large or Small

TIME:
30 - 45 minutes

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Expository

CONCEPTS:
Scaling
Angle
Altitude
Tangent
Tracking

SKILLS:
Graphing
Measuring
Plotting Angles

RESOURCES:
194

BEST COPY AVAILABLE

Method 2. Mark off the distance from the station to the pad. Let us assume that it is 1,000 feet. Assume that the rocket was tracked to its highest point and that the angle of elevation was 40°.

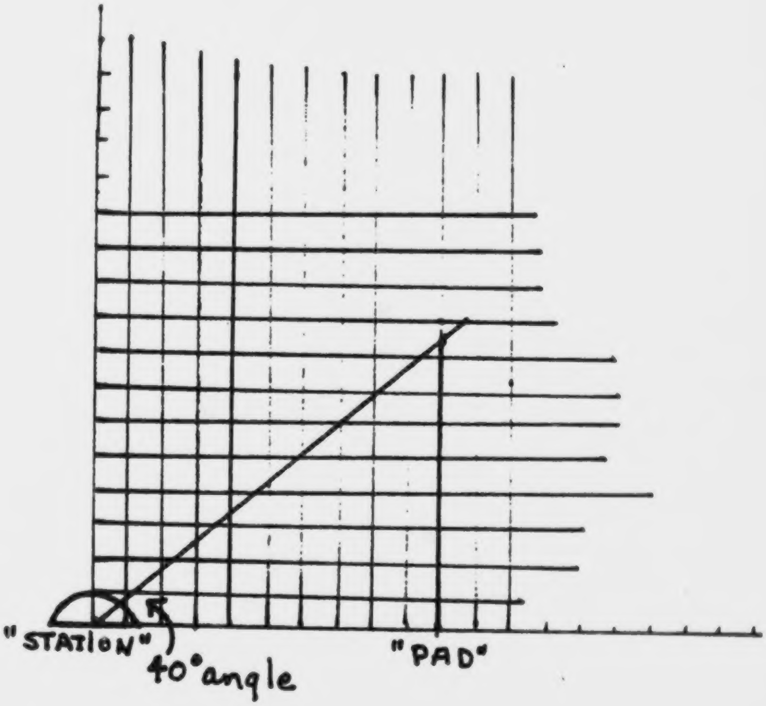
Let one square = 100 feet on the graph paper.

Draw a line on the graph paper 10 squares long paralleling the bottom of the paper.

Construct a line of any length perpendicular to the base line at the point called "pad."

Construct the angle of elevation to the perpendicular line from the point marked "station."

To obtain the elevation simply measure the length of the perpendicular side. For example: in our problem this line would be 8 4/10 squares or 840 feet.

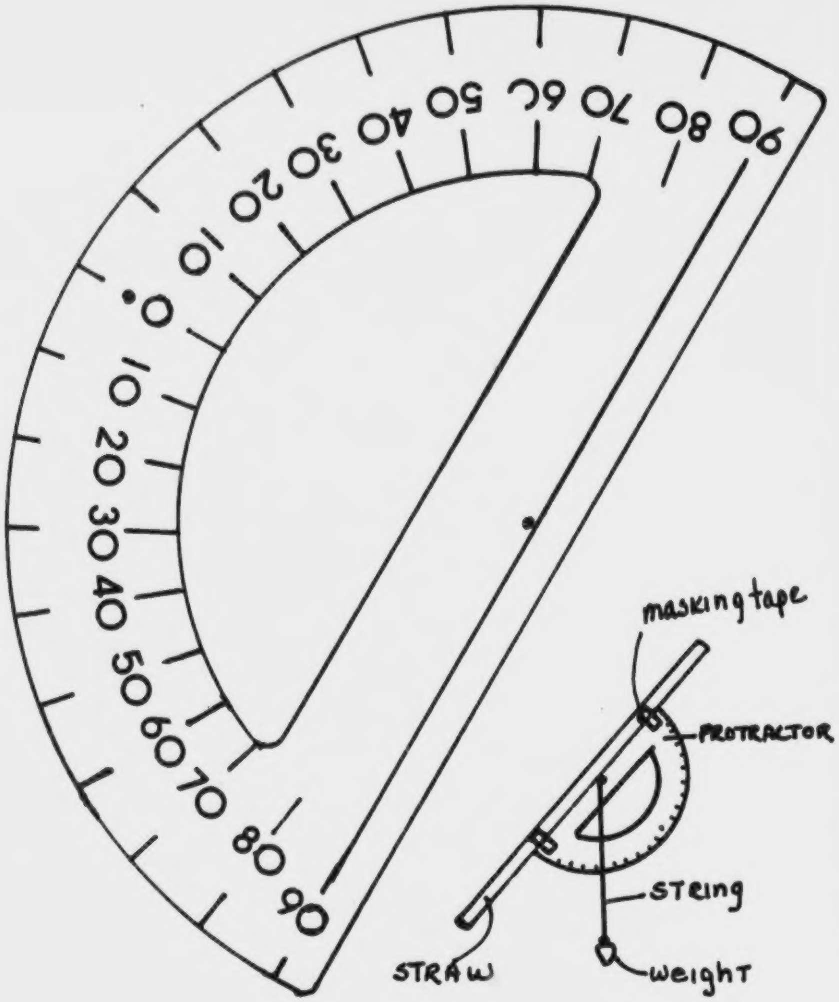


1 square = 100 FEET

(con't)

If you have no altiscope or hypsometer, have students make a sighting device using the illustration as a guide.

To use the sighting device (clinometer) hold the straw and sight the top of the building or the tree or the highest point a rocket rises through the straw. A partner should then observe the degree mark where the string crosses the protractor. To find the angle of the straw to the ground, subtract this reading from 90 degrees or use the diagram as a guide for remarking the angles on the protractor. (If you wish, you may reproduce it and glue it to the protractor.)



"DREAMS THAT YOU DARE TO DREAM"

"...BUT NOW YOU'RE OUT THERE AND WHAT YOU'VE GOT AROUND YOUR HEAD IS A GOLDFISH BOWL AND THERE ARE NO LIMITS HERE."

RUSSELL SCHWEICKERT, ASTRONAUT
DURING EVA, MARCH 1969

82. SPACE SHUTTLE SEARCH
83. SHIELDING AGAINST HEAT AND COLD
84. OXYGEN PRODUCTION
85. THINGS THAT GO ZING IN THE NIGHT
86. MUNCHING ON THE MOON
87. THE COOKIE THAT CAME TO EARTH FROM THE SEA IN ORDER TO BE EATEN IN SPACE.
88. CATCHING THE RAYS
89. SPACE INVASION
90. RECORDING HEART RATE
91. PHYSICAL FITNESS IN SPACE
92. IT'S ALL RELATIVE
93. PAPER STARSHIPS
94. DREAMS YOU DARE TO DREAM
95. CAREERS IN AVIATION AND AEROSPACE

82

SPACE SHUTTLE SEARCH

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

2 - 50 minute periods +
Several day research

TYPE OF ACTIVITY:

Student Research

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Space Shuttle
Technology

SKILLS:

Researching data
Presentation

RESOURCES:

205, 208, 229, 244,
261, 263, 276, 294

Objective: To have students find information on the Space Shuttle; to motivate students to gather and organize information to share with class.

Materials: Copy of assignment for an area to investigate. (See following pages) Books, magazines, pamphlets, etc. on the Space Shuttle. Model of Shuttle. (Following.) "Space Shuttle Statistics" sheet. (Following) Light cardboard. Scissors. Glue.

Teacher Background Information: Since the space program began, designers of space craft have built on the lessons learned with each flight and, at this point, the Space Shuttle has the most sophisticated and complex living arrangements of any "manned" spacecraft. Lessons from Mercury, Gemini, Apollo and Skylab have helped to make life for the Shuttle's passengers as safe and comfortable as possible in weightlessness.

This is important because, as we move through the 80's, there will be giant leaps in "manned" space travel. Four Shuttle Orbiters, each with accommodations for up to seven persons, are scheduled to make as many as 60 round trips a year to low Earth orbit and back. The livability aboard the Shuttle makes it possible to add other people besides the superbly trained and healthy astronauts to the list of passengers. Men and women scientists, technicians and others in reasonably good health will also ride the Shuttle.

The Shuttle will function as a "freight" carrier, a traveling repair shop, a science lab and as a factory for manufacturing products in zero gravity. In addition, and perhaps the most exciting prospect of all, the Shuttle could deliver supplies to Earth orbit to construct future space stations.

from:
"Aboard the Space
Shuttle" - NASA

Procedure: Make copies of the "Space Shuttle Statistics" sheet and the Shuttle model for the students. (I each) Make one copy of the assignments to be cut and given to each group. Talk a bit about the Shuttle and explain that they will be doing some research on specific areas of the Shuttle. Distribute the statistics

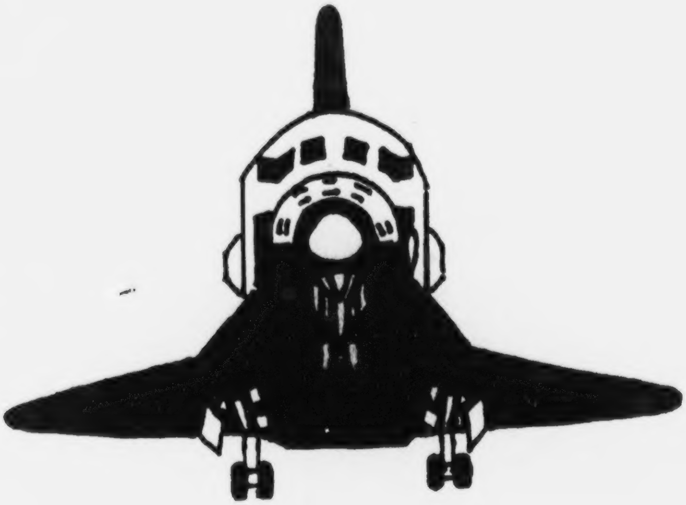
(Con't)

sheet and discuss. Distribute the model and have them cut out the pieces, glue to light cardboard and construct the Shuttle model. Talk with them about the parts of the Shuttle. When they have finished, practice flying the models and then hand out the assignments to 15 groups to investigate.

Provide books, magazines and pamphlets for the students and arrange for library time. Have the students write letters to NASA for information on their specific area if your due date for finished presentations allows.

Work with the students over a period of time on their presentations, suggesting ways to present and to organize as they require or ask for your help. Encourage as much visual material during the presentation as they can handle. Encourage them to search out information from real people, if at all possible, rather than just through written material. Set dates for the presentations that give enough time to do some real gathering of information but not so far in the future that there is no sense of immediacy.

Have students give their presentations to the class. Leave time for questions of the groups and once finished, display the gathered models, pictures, drawings, etc. in a Space Shuttle Center and invite other classes in to see.



SPACE SHUTTLE SEARCH

1. Find out how the astronauts sleep on the Shuttle. Investigate the difference between some earlier sleeping arrangements (for example, what was the sleeping arrangement on Apollo II?) and the Shuttle's facilities. Explain to the class how things have changed. Use illustrations or models to show how the astronauts sleep. Explain what time they go to sleep and what time their work day starts.

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2. Find out about the Shuttle Orbiter's food system. Find out what sort of food is eaten by the astronauts, how much, how it's prepared, stored, etc. Tell the class how the astronaut diet is figured out and where they can get similar food. Bring samples of the sort of food eaten on the Shuttle and share with the class.

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3. Find out about the space suits and head gear worn on board the Shuttle. How do they differ from earlier models for other missions? What are they made of? Are they made of male and female crew members? (Find out only about the gear worn inside the craft as another group is working on the EVA gear.) After you have your information gathered, make drawings or find pictures to show the class what the gear looks like and how it works.

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4. Find out how the Shuttle is launched. Using an illustration of the Shuttle, show the class the basic parts of the craft and explain how it gets off the ground and how it enters orbit. What kind of fuel is used? How many g's are experienced on take off? (What is a "g"?) How is the g force better now with the Shuttle than most other manned flights? How fast does the Shuttle orbit? Describe to the class what can be seen as the Shuttle orbits the Earth. Bring pictures of take off. They're beautiful. Bring pictures of what the astronauts see while in orbit.

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5. Find out about weightlessness on the Shuttle. (Did you know you'd be taller in space than on Earth? Find out why.) Explain to the class what happens in weightless conditions when you eat, go to the bathroom, take a shower or do work on board. How are the problems solved on the Shuttle? Bring pictures or drawings of astronauts in weightless conditions. Tell the class how NASA prepares astronauts to live in weightlessness.

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6. Find out why it's so important for the astronauts to exercise in space. Find out what kind of exercises do the job and what some of the problems are. Show the class a drawing of the treadmill and explain its use. Why is it important that astronauts be in good condition before they come on board? Why do they need to exercise after they get there? Why are the needs greater the longer the flight?

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7. Find out how the air manufacturing and control system inside the Shuttle works and why it's so VITAL up there where the Shuttle orbits. Why would your blood boil in space? Find out and tell the class how the Shuttle engineers keep that from happening to the astronauts. Explain how the air is purified. Bring something that illustrates to the class how the whole process works.

8. You won't be able to shower on the Shuttle, but you will be able to stay clean AND go to the bathroom when necessary. How come showering is such a problem and just how does one go about staying on the toilet seat in a weightless condition? Find out how NASA has provided for the personal hygiene of its astronauts. Find out why the fuel cells on board are so important to this provision. Explain why it's so VITAL that this aspect of space travel be carefully provided for and, while you're at it, find out why you don't have to trim your fingernails as often in space. Bring pictures or drawings of the personal hygiene facilities to show the class.

9. Find out how the astronauts, while in orbit, leave the Shuttle and why. Find out what kind of gear is used for EVA (Extra-Vehicular Activity). Find out and explain to the class the procedure used to leave the vehicle and some of the things the astronauts do outside the craft. Explain how gear protects the astronauts from the hostile environment. What would happen without it? Bring pictures or drawings of EVA to show the class.

10. Find out about the Manipulator Arm. How does it work? Why is it so helpful to the astronauts? What does it do in space? How is it like a human arm? Make a model for the class of the "space crane" showing the movable "shoulder," "elbow," and "wrist" on the "arm." Explain how it works. Bring pictures of the arm.

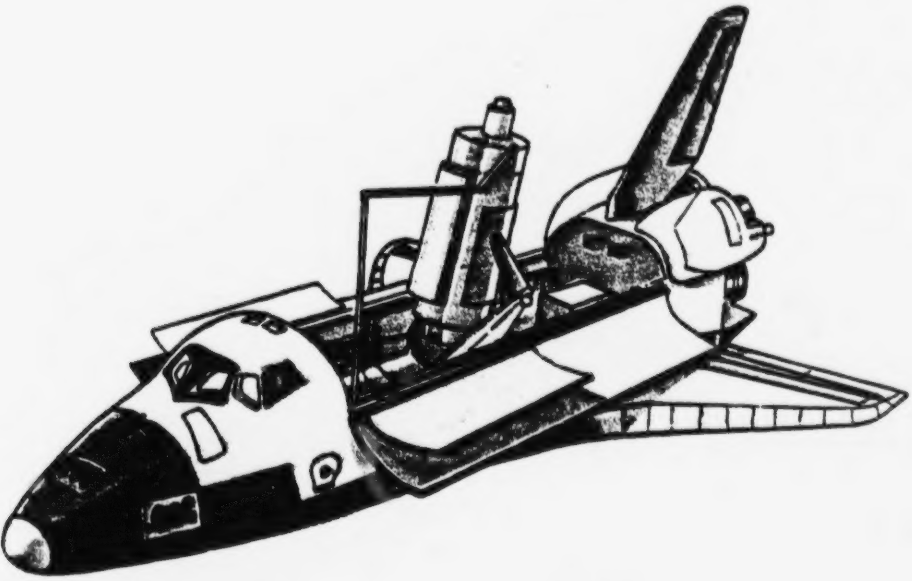
11. Find out about Spacelab. Who financed and built it? Who goes into space as "Payload Specialists?" What sort of work will be done by Spacelab? Give examples of experiments better done in space and tell the class why. Brainstorm some ideas for experiments your group thinks would be good to do in weightless conditions on board the Shuttle. Tell why you think they would be good experiments. Bring pictures or drawings of what the Spacelab looks like to show the class.

12. Find out about the Space Center (Space Station). How many people would work in it? What would it be used for? How would it be constructed? How would it be powered? How long would people stay there? Make a model of it to show to the class.

13. Find out how the Space Shuttle comes back to Earth. Find out when the astronauts begin reentry procedures and explain to the class the steps they go through to bring the craft back to the landing site. Explain how a vehicle that took off as a rocket, comes back as an airplane. How fast is it flying as it touches down? What is its angle to reentry? How does it differ from most other airplanes? What happens to the Shuttle after it returns? How is that different from other spacecraft in the past?

14. Find out about the people on board the Shuttle. Explain who the Astronaut Crew is and what the responsibilities are. Who are the Payload Specialists? What do they do? Who "mans" these trips? Why is "mans" an inappropriate verb here? Find out and tell the class how Shuttle astronauts get to be Shuttle astronauts. What are some of the requirements? Choose a couple of specific astronauts as examples, and give some details about their background. Bring pictures or drawings of people working on the Shuttle.

15. Find out about some of the benefits that come from using the Shuttle. What repairs can it make? What information can it provide in the areas of Agriculture, Communications, Scientific Study, Petroleum Resources, Mineral Resources, Pollution, the Fishing Industry and the Timber Industry? How can that information be used? What will the Shuttle be doing for us in the future, according to your reading? What things can YOU think of for it to do? Futurize a bit. Bring illustrations of how it benefits us.



Space Shuttle Statistics

The Space Shuttle is NASA's first true aerospace vehicle. It will take off as a rocket, operate in orbit as a spacecraft, and land on the Earth as an airplane. The Shuttle is a four part vehicle consisting of the Orbiter, an expendable External Tank (ET), and two Solid Rocket Boosters (SRB's).

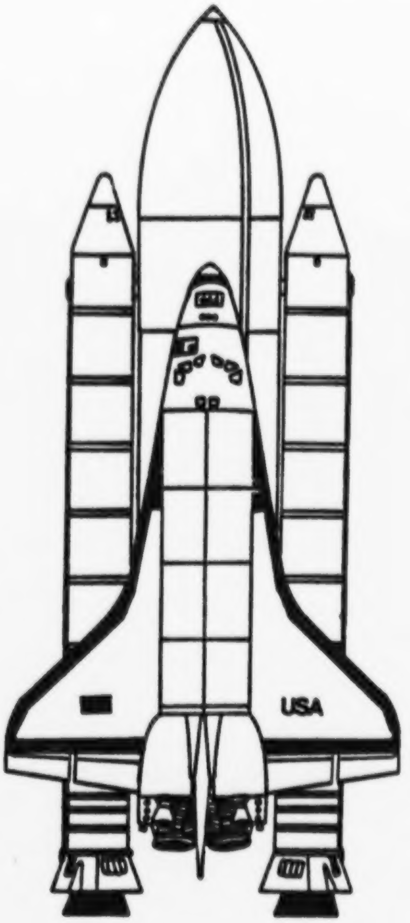
Launched in a conventional manner, the Space Shuttle's Main Engines (SSME's) and the SRB's produce approximately 30,800,000 newtons of thrust. At 45 kilometers above the Earth the boosters separate and return to the Earth by parachute for sea recovery. Eight minutes into the flight, at an approximate altitude of 110 kilometers, the ET propellants are exhausted. The tank will separate from the Orbiter and disintegrate upon reentry into the Earth's atmosphere. Any surviving pieces fall into remote ocean areas. To complete orbital insertion to altitudes between 160 and 1100 kilometers, and later to make orbital adjustments, two Orbital Manuvering System (OMS) engines fire.

Once in space, the Space Shuttle Orbiter serves as a base to deploy payloads such as satellites or space probes. Satellites needing repair or servicing can be brought on board and later released or returned to Earth. The Orbiter can also be used as a platform for scientific research.

At the completion of the orbital phase of the mission, the Orbiter is rotated in space by firing combinations of small rockets called the Reaction Control System (RCS). When the OMS engines are aimed in the direction of motion, they fire and the resulting thrust slows the Orbiter, initiating reentry. Before making atmospheric contact, the Orbiter is again rotated so that the underside will experience the major share of atmospheric friction. To protect the Orbiter, three types of reusable surface insulation are used. In areas of greatest heating, the nose area, and the leading edges of the wings, reinforced carbon is used (carbon cloth impregnated with additional carbon, heat treated, and then coated with silicon carbide). Other areas are covered with thermal tiles made of silica fibers or a Nomex felt blanket material (nylon felt coated with silicon). To aid in heat rejection, the tiles are given a glassy ceramic coating.

As the altitude and speed of the orbiter decreases, the Orbiter begins to function as a glider. The glide angle to the runway is about six times steeper than a commercial jet liner on landing approach. Landing speeds are approximately 340 kilometers per hour.

Following landing, the Orbiter undergoes refurbishment, new payloads are inserted, a new External Tank installed, the boosters refueled and the entire vehicle assembly is made ready for a new launch a few weeks later. To reduce cost, the Orbiter is designed to be used again for up to 100 missions and the SRB's are designed for 20 flights each.

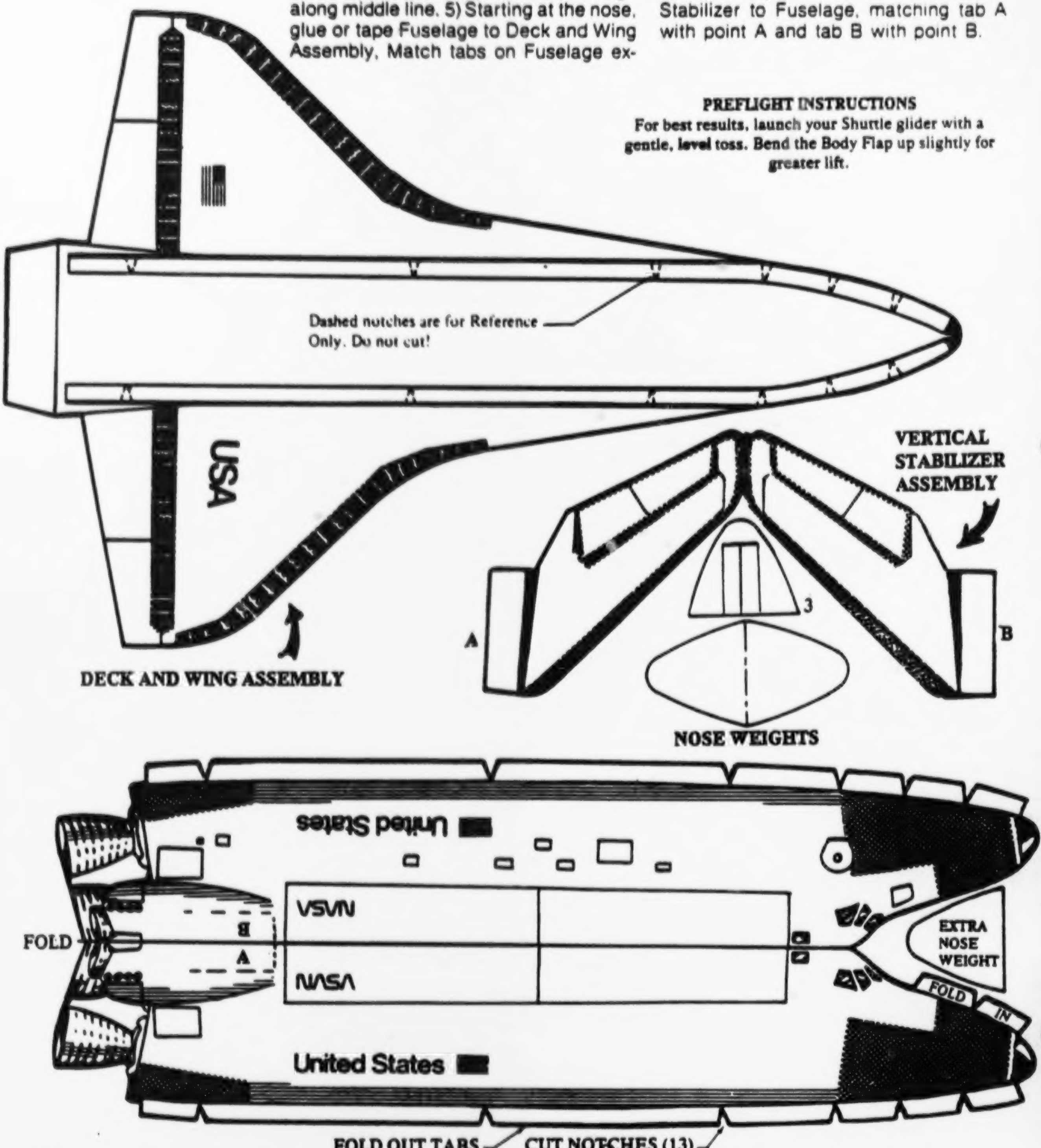


ASSEMBLY INSTRUCTIONS

Read carefully before assembly: 1) Cut out all parts using scissors. 2) Cut out V-shaped notches on Fuselage to create tabs along outside edge. Fold tabs out. 3) Glue or tape three Nose Weights to underside of nose of your glider. Use the fourth weight provided if needed for extra trim after assembly. 4) Fold Fuselage along middle line. 5) Starting at the nose, glue or tape Fuselage to Deck and Wing Assembly. Match tabs on Fuselage exactly to those printed on Deck and Wing Assembly. 6) To close the nose, glue or tape the two halves together using tabs provided. 7) Fold Vertical Stabilizer Assembly. Fold out tabs A and B. Except for Except for tabs A and B, glue or tape Vertical Stabilizer Assembly to make one solid piece. 8) Attach Vertical Stabilizer to Fuselage, matching tab A with point A and tab B with point B.

PREFLIGHT INSTRUCTIONS

For best results, launch your Shuttle glider with a gentle, level toss. Bend the Body Flap up slightly for greater lift.



83

SHIELDING AGAINST HEAT AND COLD

Objectives: To show students that various materials have varying heat absorption and radiation capabilities as well as expansion and contraction capabilities; to relate those capabilities to flight; to help students appreciate the complexity of designing space and aircraft.

Materials: (Activity I) Gooseneck lamp. Small box (cut off milk carton works). Thermometer. Various materials like cloth, aluminum foil, paper, styrofoam, metals.

(Activity II) Materials from Activity I. Flat black paint.

(Activity III) 4 short candles. Drinking straw. Metal tray. Hat pin. 2 blocks of wood. Metal rods like small round curtain rod or heavy copper wire (8 or 10 gauge).

Teacher Background Information: Shielding aircraft and passengers from heat and cold is a complicated engineering problem and spacecraft destined to make long space journeys and to return to earth will face difficulties more formidable than any ever encountered before. Among the most hazardous of the difficulties are temperatures ranging from 4,000 F in space to 15,000 F during reentry. Spacecraft designers, therefore, are constantly searching for materials and construction techniques which can withstand these temperature conditions.

Examples of effective structural designs and materials already in use include the overlapping of metal shingles on the neck of the Mercury capsule, corrugations in the skins of some of the more advanced craft and the heat protection tiles of the Shuttle. These permit scale-like and accordion-like movements when temperature changes result in expansion and contraction of the materials and/or insulation against very high temperatures.

The internal temperature of many spacecraft is partially controlled by using different types of construction materials and painting them in patterns of black and white or of colors. Thus, the absorption and radiation of heat by the craft can be balanced to some extent and the on-board equipment can operate in temperatures that approximate those within the earth's range.

(Con't)

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

30 minutes per activity

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Absorption
Radiation
Expansion/Contraction

SKILLS:

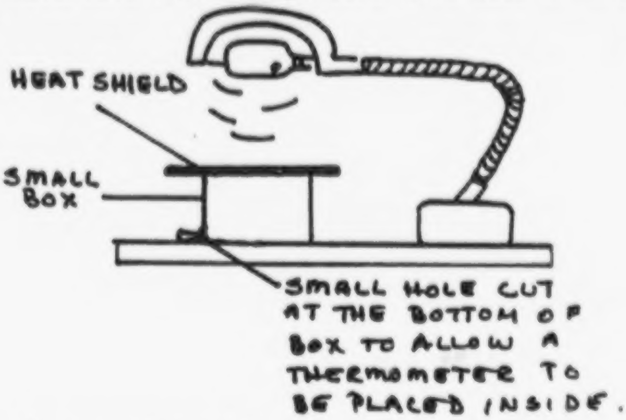
Collecting/Recording data
Observation
Inference
Prediction

RESOURCES:

210, 290, 296, 298

Procedure: Simple experiments, which yield quantitative results, can be done in the class to test the heat resistant qualities of certain materials.

Activity I: Make a hole large enough for a thermometer in the side, at the bottom of a small box. Cover the top of the box with a material you want to test. Record the temperature of the box (room temperature) and record the rise in temperature inside the box over a given period of time after turning on the light bulb which provides your heat source. After the recordings have been made, have students graph the results of materials tested and temperatures reached. Discuss which of the materials absorbed the greater amount of heat and which reflected back heat, keeping the box cooler. Relate this to the shielding of aircraft against the heat of rocket blasts and atmospheric friction in reentry. Have students find the kinds of materials NASA's engineers have used or are testing now.

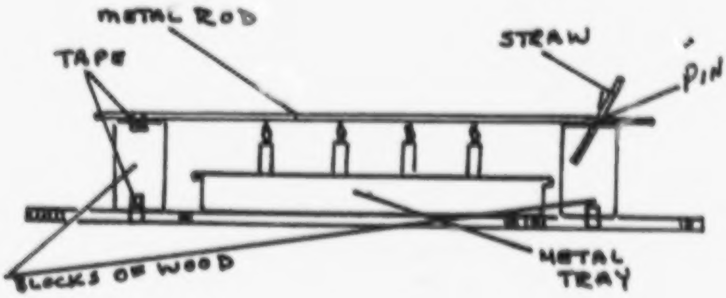

HEAT SHIELD
SMALL BOX
SMALL HOLE CUT AT THE BOTTOM OF BOX TO ALLOW A THERMOMETER TO BE PLACED INSIDE.

Activity II: To experience the way some colors absorb more heat than others, paint some of the materials used in Activity I with flat black paint. Repeat the experiment and record the differences in temperature of the test materials when they are exposed to the heat source. Discuss the differences after they write up their observations and relate to the internal temperature of an aircraft. Problem to solve: If the Sun is shining on one side of the craft and the other side is in the cooler shaded side, how might the craft maintain a constant comfortable temperature inside? Brainstorm ideas. (In-

(Con't)

sulation--Cooling/heating systems--rotation of craft) Have students research what NASA engineers and aircraft engineers do.

Activity III: Use a straight metal rod about 60 cm long. Place ends on two blocks of wood. Tape blocks in place to table and tape one end of the rod to the block. It's important that the blocks and one end of the rod be stationary. Cut drinking straw in half and stick a pin through the middle of one half to serve as a "pointer." Set the pin on the block and rest the rod on it with the straw straight up and down.



Put the metal tray with 4 short candles placed in a row, under the rod. Light the candles and observe what happens. Ask the students to write their observations. What physical changes took place? What inference can be made here? (Why does the "pointer" move as it does?)

Ask students to predict what will happen when the candles are blown out? Check it out. (EXTRA: Put ice in a plastic bag and wrap around rod. What happens?) Discuss the implications of metal expansion and contraction in designing aircraft and spacecraft. Brainstorm some ways the students think aircraft and spacecraft engineers might take care of this problem. (Overlapping--use of corrugated material--flexible joints.) Have them research what the designers do.

84

OXYGEN PRODUCTION

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

45 minutes for A & B
40 minutes for C

TYPE OF ACTIVITY:

Experiment

TEACHING STRATEGY:

Guided Discovery and Expository

CONCEPTS:

Oxygen production
Compounds
Elements

SKILLS:

Experimentation
Inference
Data Collection/Recording

RESOURCES:

207, 210, 212, 219, 238, 255, 296, 297

Objective: To learn that oxygen can be produced in various ways for space flight.

Materials: Dry yeast. Heat resistant bottle. Hydrogen peroxide (6 percent). Activated charcoal. Cardboard. Splint. Elodea plant (from fish store). Test tube. Glass funnel.

Teacher Background Information: Oxygen is an odorless, colorless gas. It makes up about 20 percent of the air. It is slightly heavier than air and is a necessary component in supporting life. Whenever anything burns, it unites with oxygen.

Since it's so vital to survival, oxygen must be carried along and delivered to the astronaut in regular and uniform concentration. There are several methods of supplying oxygen. One is to carry the total supply in containers either in gaseous or liquid state. Another method is to obtain oxygen from certain oxygen compounds. A third is to have green plants along, such as algae, to produce oxygen. A fourth method would be to split the oxygen away from the carbon dioxide breathed out by the astronaut. These three simple experiments can be done to show the students how it is possible to produce oxygen with plants and by breaking down oxygen compounds.

Procedure: Talk with the students about the critical need for oxygen that humans have. Talk about oxygen as part of our environment and how we must replace the hostile environment of space with a more friendly one if we are to survive. Discuss the difficulty of providing for oxygen only by carrying tanks of it on board. (Weight, space, safety and mobility, for example.) Explain that they will be producing oxygen in these experiments in ways similar to those used by NASA.

A.) Have students place one tablespoon of dry yeast in the bottom of a heat-resistant bottle or flask. When I tablespoon of hydrogen peroxide is added, a bubbling of oxygen gas will result. The gas can be collected in the flask by holding your thumb over the top or covering it in some way until a glowing splint can be put into it. What happens to the splint?

B.) Put a heaping spoonful of pieces of activated charcoal into a container such as a heat-resistant baby

(Con't)

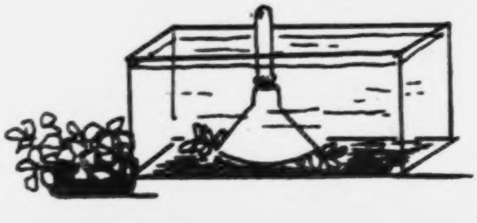
bottle. Cover the charcoal with 6 percent hydrogen peroxide and cover the bottle with a sheet of cardboard to trap the oxygen that is produced. Test for oxygen with the glowing splint. What happens? (Glows more brightly or bursts into flame)

Have students write up their observations by describing their experiments and the results observed. Then, discuss why the splint burst into flame and have them write what can be inferred as a result of that.

Discuss why the splint bursting into flame indicates the presence of oxygen? Where does the oxygen come from? What compound is involved here? (H_2O) What is a compound? What is an element? What two elements are involved in this experiment? How can the students tell? If hydrogen and oxygen are both odorless and colorless, what sort of evidence does one have to have in order to know they are present? (NOTE: Why would it be dangerous to have open containers of hydrogen gas on board? Why would a "No Smoking" sign be in order, besides the fact that it's already dangerous to an astronaut's health? Because of the high flamability of pure oxygen, NASA now uses a combination of oxygen and nitrogen for breathing. That's closer to the actual earth's combination anyway.)

C.) Place an elodea plant under an inverted clear plastic or glass funnel in an aquarium. Place a test tube filled with water over the funnel stem. Allow several days to pass being sure the plant has plenty of sunlight. Note the change in the water level of the test tube. After most of the water has been displaced (by oxygen), remove the test tube. Test for the presence of oxygen by placing a glowing wood splint in the test tube. Write up the experiment and have students infer what they believe has happened.

Discuss growing green plants in space for producing oxygen. What might be some of the difficulties? What advantages? Have students do some research on how NASA uses algae to produce oxygen on space flights. Have students design an imaginary "Space terrarium and oxygen collector" for a group of imaginary space travelers. Make a model or drawing of it. Make it wild but based on what they know, at this point, to be scientifically true.



85

THINGS THAT GO ZING IN THE NIGHT

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

2 - 45 minute periods

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Meteoroids
Micrometeoroids
Velocity
Friction

SKILLS:

Observation
Collection and
Recording data
Inference

RESOURCES:

136, 172, 213, 243, 255

Objectives: To show that small particles at tremendous speeds can penetrate objects; to show students that earth is bombarded by micrometeoroids constantly.

Materials: (Activity I) Raw Potato. Plastic straws. (Activity II) Strong horseshoe magnet. 6 feet of cord or rope. Tweezers. Powerful magnifying glass or rock and mineral microscope (dissecting Scope). Samples of gathered magnetic particles.

Teacher Background Material: Most of us have at one time or another seen "falling stars" or "shooting stars." These are bits of material which have been heated to incandescence by the friction of the air. Those pieces which are sufficiently large to not vaporize completely and reach the surface of the Earth are termed meteorites. The incandescent trail which forms as these "falling stars" hurtle through space is termed "meteor." The chunks of material, in space, are called meteoroids.

Meteoritic samples vary from tiny dust grains to giant boulders having masses of several thousand kilograms. It is difficult to distinguish meteorites from terrestrial rocks but there are some distinguishing characteristics that can be used to determine the difference. A round, melted looking piece or a triangular shape with what appear to be tiny "thumb prints" on the side are characteristic of meteorites, for example.

Estimates indicate that perhaps as little as 1,000 to more than 10,000 tons of meteoritic material falls on the Earth every day. However, most of this material is very tiny - in the form of micrometeoroids or dust-like grains a few micrometers in size. Analysis of ocean sediments show the presence of large quantities of micrometeorites and considering the proportion of ocean to land, the majority of meteorites should fall into the water.

In spite of the vast infall of meteorites, there are only two documented cases of anyone being hurt or killed by meteorites. A shower of stones which fell near Alexandria, Eygpt in 1911 killed a dog and in 1954, in Alabama, Mrs. Hewlett Hodges was severely bruised by an 8 pound meteorite that crashed through her roof.

An interesting note here is that there are micrometeoroids so small and travelling so fast, they can

(Con't)

actually pass right through a house or a space craft without notice. While a large meteor "strike" would be disasterous, these collisions with micrometeoroids could go on without any of us being aware that we are colliding with objects from space.

Procedure: (Activity I) To show the penetrating power of a projectile which has a small mass but a high velocity, hold a raw potato in one hand (between the thumb and index finger). Do not hold it in the palm of your hand.

With the straw in the other hand, try to drive the straw through the potato. Do it slowly at first and observe what happens. (Not much except crinkled straws.) Increase the velocity. What happens? What happens when the straw's velocity is increased and you move the potato quickly toward the oncoming straw? Relate this to moving vehicles or objects in space. (You might want to relate it to driving an automobile too fast for a quick reminder of that danger as well.) Repeat the experiment, using different sizes of straws. What happens?

Have students write up their observations. After a discussion about why the straw is able to penetrate the potato, have them write up the inferences that can be made. Have them write up their conclusions about how size and speed affect the ability of the straw to penetrate the potato.

Extension: Spacecraft engineers have developed "bumpers" on space craft as one method of protecting crafts in case of a collision with a meteoroid in space. Have the students consider protective measures against meteoroids and draw or construct a model of a space craft with the devices they have come up with. (Bumpers, laser beams, warning systems, etc.)

(Activity II) Very small meteorites can sometimes be found by dragging a magnet through the dirt outside and inspecting the pieces which "stick" to the magnet with a magnifying glass or under a microscope.

Tie a length of strong cord to a horseshoe magnet and drag it through the dirt for ten or fifteen minutes. Try to find an area that is not heavily walked on. Bring the material that clings to the magnet inside and carefully remove the material. Place the material under a scope or inspect with a strong magnifying glass. Look for the characteristics mentioned (round, melted side or the "thumb prints").

86

MUNCHING ON THE MOON

SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Large

TIME:
60 minutes

TYPE OF ACTIVITY:
Student Investigation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Calories
Nutrition
Food System

SKILLS:
Interpreting data
Collecting data
Futurizing

RESOURCES:
205, 221, 229
244, 260, 276

Objectives: To provide students with information on the food system of the space shuttle; to have students plan a balanced menu for space flight; to futurize on food needs when colonizing space.

Materials: Information sheets - "Food System," and "Eating In Space: Calorie and Weight Chart." Samples of "space food." Pencils.

Teacher Background Information: In long term space flight, the food carried aboard must remain free from spoilage or decomposition and must contain all the essential nutrients in order to maintain a proper state of health. In the NASA missions, the diet of each astronaut is carefully controlled and monitored. Food items are carefully analyzed for the major as well as trace biochemical constituents. The activity which follows takes into consideration only the weight of the food and water used in a typical day's diet and the Calories recommended. The students should be told that NASA works out a diet consistent with the recommended daily dietary allowance of several items: Protein, Fat, Carbohydrate, Water, Minerals, Vitamins and Trace Minerals. A complete listing of these can be obtained from NASA. NOTE: The list of foods on the Calorie and Weight Chart is a partial listing of the foods available to the astronauts. A complete list can also be obtained from NASA.

Procedure: Have the students assume that they are space travelers. They are allowed to bring on board 950 grams of food stuffs for each day, are allowed a maximum of 1350 grams of water to reconstitute their food each day and are allowed 3,000 Calories for each day, divided into 1100 (Breakfast), 1100 (Lunch), and 800 (Dinner). Have them work out the best (most nutritious and close to the numbers allowed) day's worth of menus they can. Before they go to work, talk with them about nutrition, balanced meals and the need for exercise to work off some of the Calories. Why do they think the recommended Caloric allowance for Gemini was 1,800 Calories while the Apollo Mission was given 2,000 Calories, Skylab between 2,200-2,400 Calories and the Shuttle folks 3,000 Calories. Have them find out what some of the reasons were.

(Con't)

Have students keep a one-day record of what they eat, how much it weighs and how many Calories it contains. Compare kinds of food, weight and Calories with the Astronauts' diets. Is there a difference in nutritive value? In fiber content? Why is it so important to have low residue diets in space?

Talk about the problem of food in space over long periods of time. A year perhaps. Or 96 years. What would be necessary to grow food in space? What kinds of food could be grown most feasibly? Have students do some research after brainstorming the problem. They'll run into some fascinating (sometimes pretty yuchy sounding) possibilities. Talk about nutrition in a capsule. Problems? (If we could get them to set our taste buds off properly and time release them so that the soup course went off before the entree and the chocolate mousse came last, we'd be in business!!)

Extension: Bring in samples of dehydrated, thermostabilized, irradiated or intermediate moisture foods and compare to natural food. Dried fruit, granola and foods like macaroni and cheese in a package are very easy to find in regular stores. Other stores will have even more "far out" foods on hand. There are a number of companies that manufacture food for NASA as well as for campers and hikers and they can be found at sporting goods stores, health food stores and camping supply stores. Do some taste testing. You'll love the freeze dried ice cream....

Food System

The Orbiter is equipped with food, food stowage, and food preparation and dining facilities to provide each crewman with three meals per day plus snacks and an additional 96 hours of contingency food. The food supply and food preparation facilities are designed to accommodate flight variations in the number of crewmen and flight durations ranging from two crewmen for 1 day to seven crewmen for 30 days.

The food consists of individually packaged serving portions of dehydrated, thermostabilized, irradiated, intermediate moisture, natural form, and beverage foods. The food system relies heavily on dehydrated food, since water is a byproduct of the fuel cell system onboard the Orbiter. Off-the-shelf thermostabilized cans, flexible pouches, and semirigid plastic containers will be used for food packaging.

The menu will be a standard 6-day menu instead of the personal-preference type used in previous programs. The menu will consist of three meals each day plus additional snacks and beverages . The daily menu will be designed to provide an average energy intake of 3000 calories for each crewmember. The food system also includes a pantry of foods for snacks and beverages between meals and for individual menu changes

The galley, which is located in the cabin working area (fig. 5-11), is modular and can be removed for special missions. In addition to cold and hot water dispensers, it will be equipped with a pantry, an oven, food serving trays, a personal hygiene station, a water heater, and auxiliary equipment storage areas. The oven will be a forced-air convection heater with a maximum temperature of 355 K (82° C or 180° F). There are no provisions for food freezers or refrigerators.

Food preparation activities will be performed by one crewman 30 to 60 minutes before mealtime. The crewman will remove the selected meal from the storage locker, reconstitute those items that are rehydratable, place the foods to be heated into the galley oven, and assemble other food items on the food trays.

Meal preparation for a crew of seven can be accomplished by one crewmember in about a 20-minute period. Utensils and trays are the only items that require cleaning after a meal. Cleaning will be done with sanitized "wet wipes" that contain a quaternary ammonium compound. As on the Skylab flights, the crewmembers will use regular silverware.

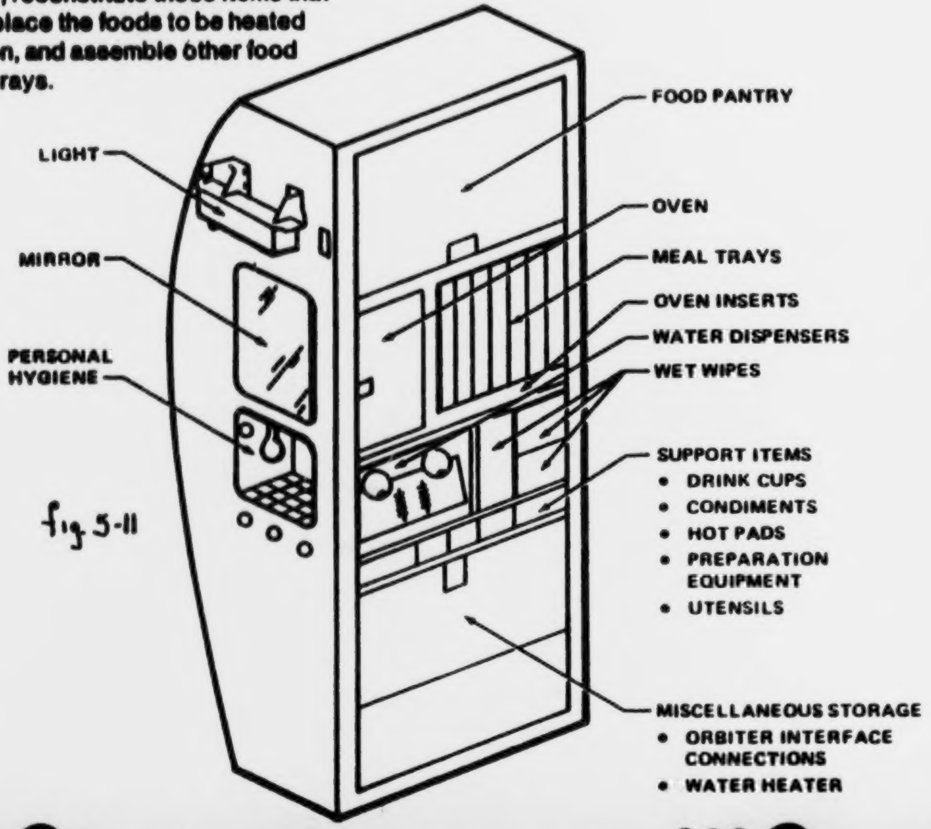


fig. 5-11

SPACE SHUTTLE TYPICAL MENU

Dried apricots (IM)
Breakfast roll (I) NF)
Granola w/blueberries (R)
Vanilla instant breakfast (B)
Grapefruit drink (B)

Tuna (T)
Macaroni and cheese (R)
Peas w/butter sauce (R)
Peach ambrosia (R)
Chocolate pudding (T) (R)
Lemonade (B)

Ground beef w/
pickle sauce (T)
Noodles and chicken (R)
Stewed tomatoes (T)
Pears (FD)
Almonds (NF)
Strawberry drink (B)

EATING IN SPACE

Calorie and Weight Chart

FOOD ITEM	WT(g)	H_2O Recon.	CAL.
Almond Crunch Food Bar	45.0	0.0	258
Almonds	45.0	0.0	318
Apple Sauce	140.0	0.0	111
Apricots, Dried	62.0	165	165
Asparagus	8.4	60.0	32
Bananas, Freeze Dried	12.0	0.0	47
Beef Almondine	31.0	0.6	153
Beef and Gravy	135.0	0.0	190
Beef, Ground w/spice sauce	145.0	0.0	178
Beef Patty	32.5	60.0	153
Beef w/BBQ sauce	140.0	0.0	224
Beef Steak	85.0	0.0	211
Beef Stroganoff w/Noodle	34.0	120.0	189
Branflakes w/NFDM & Sugar	43.5	60.0	176
Bread, Rye, Seedless	30.0	0.0	79
Breakfast Roll	100.0	0.0	431
Broccoli Au Gratin	20.0	60.0	114
Brownies	50.0	0.0	273
Butter Cookies	30.0	0.0	150

FOOD ITEM	WT(g)	H_2O Recon.	CAL.
Cashew Nut	45.0	0.0	307
Cauliflower w/cheese	16.0	60.0	90
Cheese Spread	36.0	0.0	148
Chicken ala King (T)	139.0	0.0	144
Chicken and Rice	33.0	90.0	169
Chili Mac Beef	36.0	120.0	178
Chocolate Chip Food Bar	45.0	0.0	255
Chocolate Covered Cookies	55.0	0.0	285
Chocolate Pudding	144.0	0.0	207
Corned Beef (I)	80.0	0.0	146
Cornflakes w/WFDM	40.0	60.0	156
Dried Beef	30.0	0.0	68
Frankfurter	107.0	0.0	300
Fruit Cake	80.0	0.0	336
Fruit Cocktail	140.0	0.0	99
Graham Crackers	14.8	0.0	66
Green Beans and Broccoli (R)	19.0	90.0	69
Green Beans w/mushrooms	9.0	90.0	31
Ham	115.0	84.5	117

EATING IN SPACE
Calorie and Weight Chart (Con't)

FOOD ITEM	WT(g)	H_2O Recon.	CAL.
Jelly	14.2	0.0	37
Lemon Pudding	135.0	0.0	173
Life Saver	5.0	0.0	19
Macaroni and Cheese (R)	32.0	90.0	166
Mayonnaise	11.5	0.0	93
Meat Balls w/BBQ sauce	130.0	0.0	267
Cream of Mushroom Soup	17.0	180.0	49
Mustard	5.4	0.0	4
Noodles and Chicken	28.0	90.0	143
Peach Ambrosia	36.0	60.0	174
Diced Peach	140.0	0.0	99
Peaches, Dried (IM)	62.0	0.0	163
Peanut Butter	36.0	0.0	230
Pecan Cookie	62.0	0.0	318
Peanuts, Dry Roasted	45.0	0.0	99
Pears, Diced	140.0	0.0	24
Pears (FD)	6.0	0.0	171
Pears, Dried (IM)	62.0	90.0	129
Green Peas w/butter	30.0	100.0	357

FOOD ITEM	WT(g)	H_2O Recon.	CAL.
Pineapple, Crushed	140.0	0.0	79
Potato Patty	29.5	90.0	144
Rice Pilaf	25.0	90.0	111
Salmon	110.0	0.0	180
Sausage Patty	34.0	60.0	182
Scrambled Egg	34.5	90.0	217
Short Bread Cookie	30.0	0.0	159
Shrimp Cocktail	35.0	90.0	151
Soda Crackers	44.0	0.0	213
Spaghetti w/meat sauce	32.0	90.0	177
Stewed Tomatoes	144.0	0.0	47
Strawberries	23.8	60.0	90
Tea	1.0	240.0	3
Tea w/lemon and sugar	21.0	240.0	82
Tea w/sugar	13.5	240.0	53
Tropical Punch	25.0	240.0	96
Tuna	95.0	0.0	130
Turkey and Gravy	131.0	0.0	133
Vanilla Instant Breakfast	55.8	180.0	228

87

THE COOKIE THAT CAME TO EARTH FROM THE SEA IN ORDER TO BE EATEN IN SPACE!

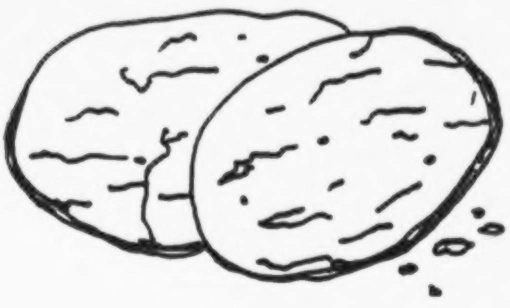
Objective: To illustrate the use of algae as food.

Materials:
- 4 tablespoons concentrated chlorella (algae)*
- 2 cups flour
- ½ teaspoon salt
- 4 tablespoons shortening
- 3/4 cup milk
- 3 teaspoons baking powder

Procedure: Cream shortening. Add dry ingredients and milk. Roll out in ½-inch sheets. Spread with mixture of sugar, cinnamon, and butter. Roll up and slice into pinwheels. Bake at 350 for 10 minutes.

Share cookies with class and discuss growing algae in space as food for people living there. Why is it such a probable source for nutrition? How is it being used now? How does it taste??? Have students research the way NASA is using this food source. Futurize a bit on using it in the future in space colonies.

* Chlorella or algae can be obtained from various biological supply houses and some health food stores.



SUBJECT:
Science

GRADE:
Sixth

TIME:
30 minutes

GROUP SIZE:
Large

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Expository

CONCEPTS:
Food Source
Algae

SKILLS:
Munching!
Inference
Researching

RESOURCES:
28

88

CATCHING THE RAYS

SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Large

TIME:
60 minutes

TYPE OF ACTIVITY:
Demonstration

TEACHING STRATEGY:
Expository

CONCEPTS:
Solar Energy

SKILLS:
Observation
Recording data
Inference
Futurizing

RESOURCES:
166, 210, 298

Objective: To help students understand that the sun's energy can be used directly; to become aware of various ways the sun's energy might be used in space.

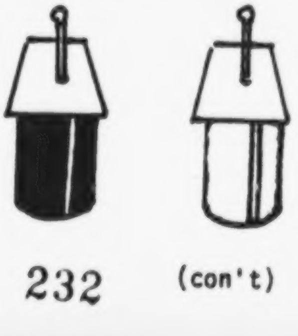
Materials: Guide sheet (See following). Light cardboard. Aluminum foil. Glue. Scissors. Paper punch. Paper fasteners. 2 tin cans. Flat black paint. 2 thermometers. 2 pieces of cardboard for covers.

Teacher Background Information: Almost all our energy comes from the sun - directly or indirectly. As the students get into the futurizing unit, do some experiments with solar energy that help them to see the wide variety of possibilities for solar. Collect articles and pictures showing its use and display them. Talk with them about when solar can be used - furnaces, solarcells, water heaters, cookers, food dehydrators, etc. There is a great deal of information on solar projects available, since it is becoming apparent that we cannot go on using up nonrenewable resources the way we are. This exploration of solar energy has immediate impact for students now on Earth as well as possible uses for the future both on Earth and in space.

There are a myriad of activities on solar from which to choose. The two following are simple, but should help your students to appreciate the energy that can be put to work here.

Procedure: Activity I - To show students why solar heaters are often made of black metal, cut the lids off two cans. Paint one flat black and leave the other as is. Cut two pieces of cardboard and punch a hole in each, just large enough for thermometer to go through. Fill both cans with water and record the temperature making sure both cans have water the same temperature.

Put the lids on the cans and set both in the sun. Every 5 minutes, check the temperature of each and record. Which can warms faster? Ask why the students think this happens? Which is absorbing better? How could this be



(con't)

related to using the sun's energy here on Earth? In space?

Activity II - Cut out 8 light cardboard pieces using the guide on the following page.

Score optional holding tabs on the ridge fold line.

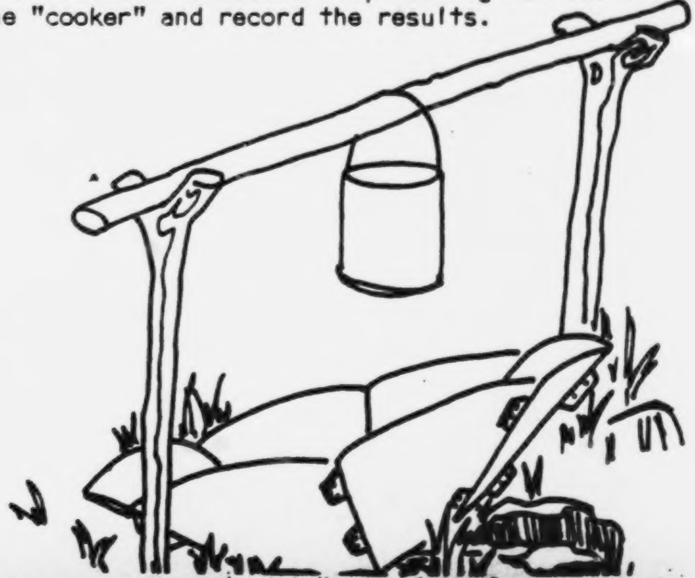
Punch all holes with a paper punch being careful to be exact so they will line up.

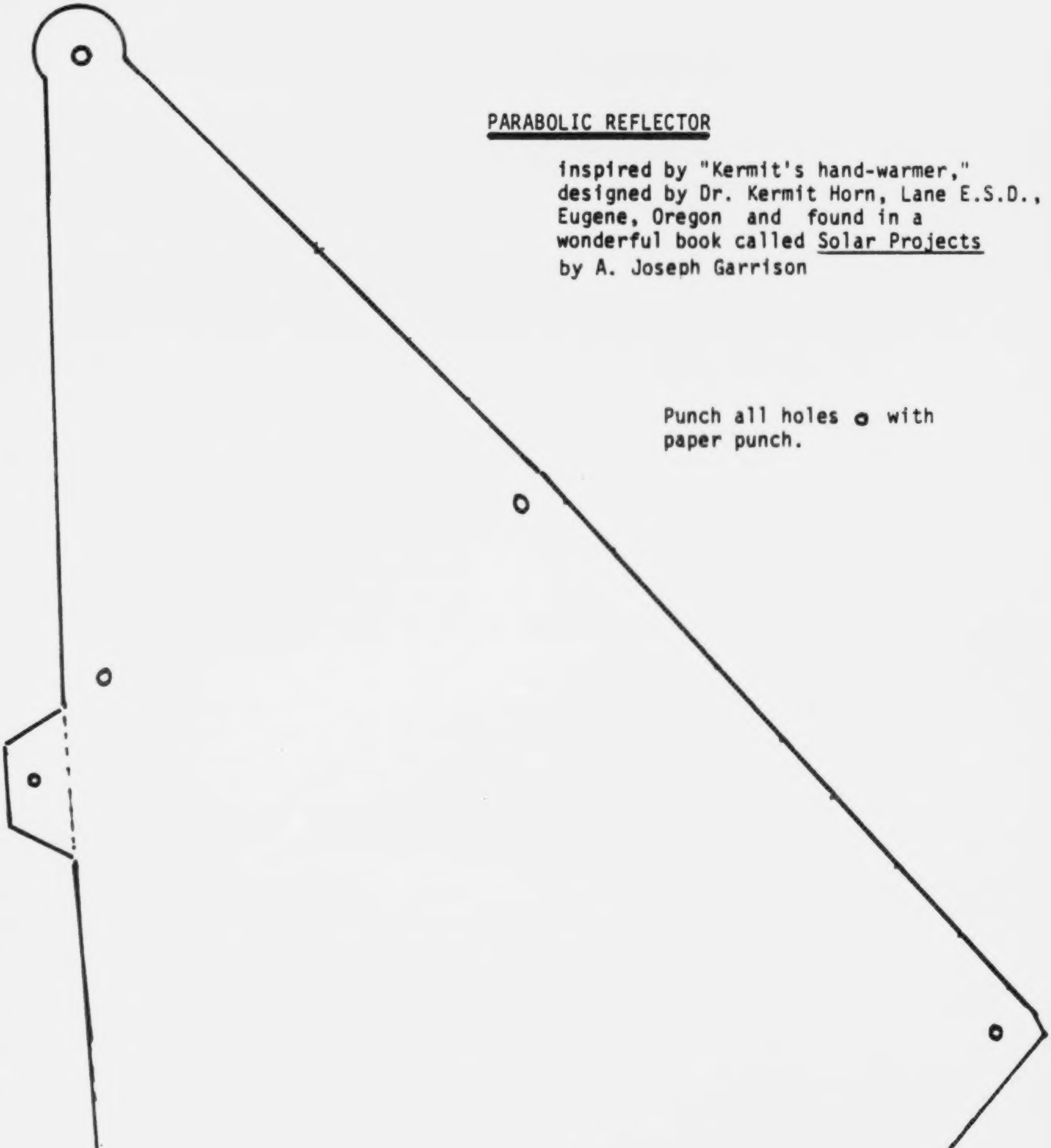
Cover all eight pieces with aluminum foil and glue in place. (Spray glue works really well.) Smooth out the wrinkles very carefully with a soft cloth.

Starting with two pieces and working in a counter-clockwise direction, hold the two edges together, then insert paper fasteners through the punched holes on the edge. (The round head should be placed on the inside next to the reflective surface.) Continue until the next-to-last piece and cut the tabs off it. This will allow the last piece to be placed on the outside.

After attaching the second to the last piece, place the last piece on the outside of the very first piece and the second to the last one, then insert paper fasteners into the remaining holes. This should lock the entire reflector into an approximate parabolic curve and complete the assembly.

This is a portable parabolic reflector and no base is provided. You might scoop out earth, or balance it against stones or rocks, etc. when you want to use it. You could, of course, build a base for it, if you have the time and are so inclined. The simplest method is to use it as shown in the illustration with the object to be heated attached to a device above the parabolic reflector at the height of the focal point. (The focus is 7 1/16" from the base.) Try heating various items with the "cooker" and record the results.





PARABOLIC REFLECTOR

inspired by "Kermit's hand-warmer," designed by Dr. Kermit Horn, Lane E.S.D., Eugene, Oregon and found in a wonderful book called Solar Projects by A. Joseph Garrison

Punch all holes ○ with paper punch.

89

SPACE INVASION

Objectives: To increase student's awareness of the individual's responsibility to others; to help students see Earth as a unique environment in space.

Materials: Books, pamphlets, magazines on Waste Control and Disposal. Paint. Paper. Garbage cans (school or community). I plastic garbage bag per student. Scale.

Procedure: Activity I--To help students understand how much garbage individuals dump into the environment and the importance of not polluting space, give students I plastic garbage bag and explain that they are to collect all the stuff they would ordinarily throw away over a 2 or 3 day period. Talk with them about it and do some predicting about how much they think they'll have in volume and weight. Have them decorate the bags and relate this activity to space. The Earth is a unique space capsule with an environment that needs looking after just as a capsule away from the Earth in space has very specific needs. One of those needs is to keep it from contamination or danger from debris.

After the students have collected their garbage, have them each weigh it and record the weight. Have fun! Who collected the most? How much did the whole class collect? Do some projecting--how much would that mean given the population of the school? Community? State? U.S.? What sort of stuff was in those bags? What might have been unnecessary--excess wrapping, for example? How much volume was there? How could volume and weight be reduced? What problems arise with some of the solutions? Noxious gases? Is recycling an alternative? Why is it so important to deal with this problem both on Earth and in Space? What can be done?

Activity II--In order to extend the classroom notion of garbage as space debris, have students brainstorm ideas for posters and sayings and turn garbage cans into Space Debris Containers. Have them work out details for a project in school or in the community. Find out how waste is taken care of and what it costs. What kind of restrictions are there in the school or community? What kind of restrictions are there in space?

Extension: Have students bring in a special piece of garbage (a can, box, bottle, etc.) and turn it into a space object.

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Large

TIME:

2 - 45 minute periods

TYPE OF ACTIVITY:

Student project

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

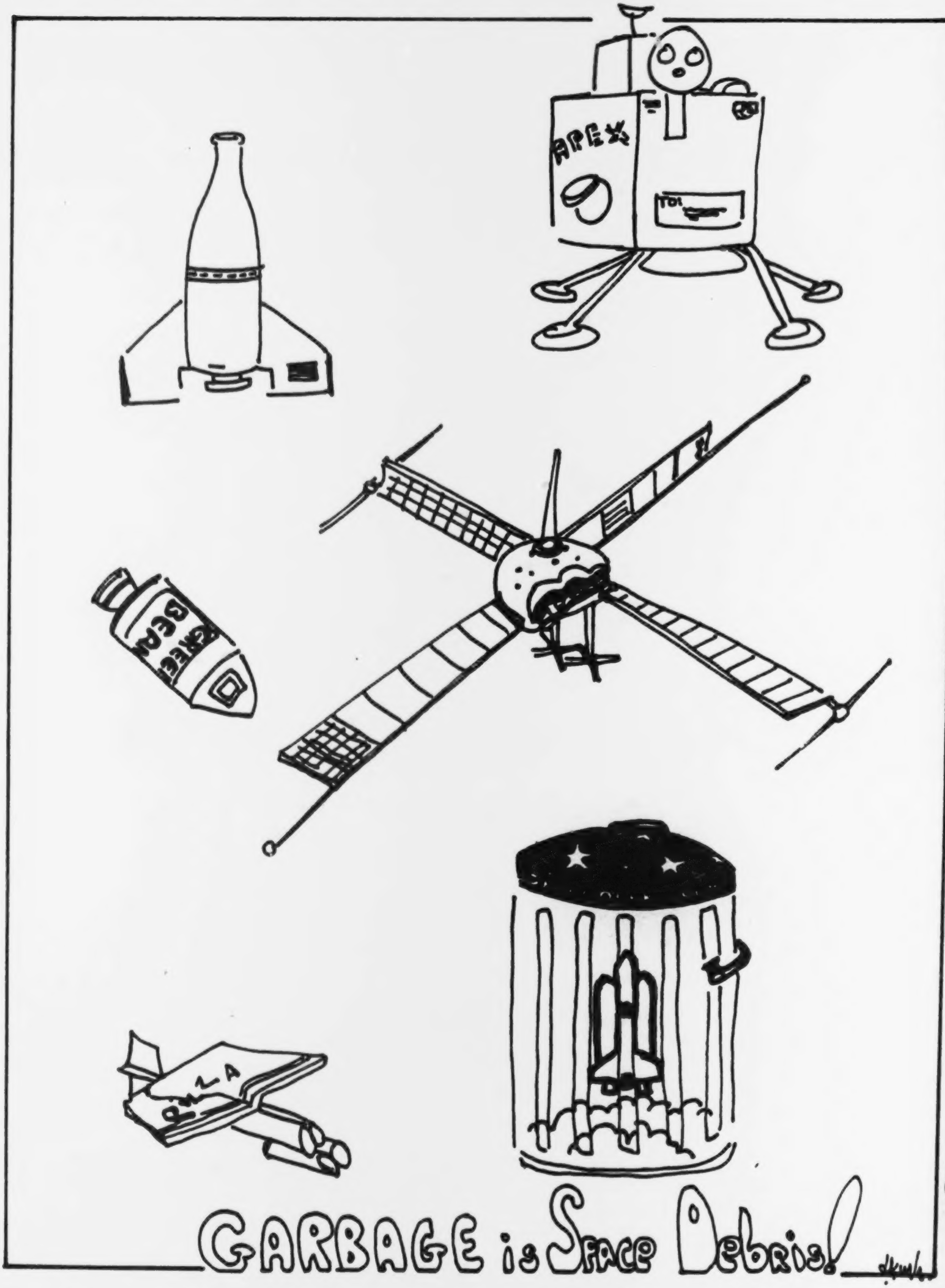
Waste Disposal
Individual's responsibility to community

SKILLS:

Collecting/Recording data
Inference
Designing project

RESOURCES:

216, 220, 231, 255



APEX
GARBAGE is Space Debris!

90

RECORDING HEART RATE

Objective: To depict the differences in heart rates during various activities; to show importance of accurate recording before and during space activity.

Materials: Watch with second hand. Worksheet (See following page). Pen or pencil. Ruler.

Teacher Background Information: This activity is to be used to show the differences in heart rate in students during various Earth activities. No immediate biomedical conclusions should be made, but extended observations and graphing may be useful in helping to illustrate heart rate averaging and limits in relation to exercise and rest in individuals.

Procedure: Talk with students about the importance of stamina and good health for astronauts and pilots. Talk about the need to have accurate records before astronauts leave Earth and the need to keep records while they are in space. How is that done? Why is it important?

Show students how to locate pulse or heart beat. Pulse is taken with forefinger held against the inside of the wrist. Have them count the heart beat for 15 seconds and multiply by four. Have them do it with other students and do their own until they have a bit of expertise.

Brainstorm several activities they could do in the classroom or in the hall, on the stairs or on the playground. (Walk vigorously for 3 minutes up and down the hallway; run in place for 3 minutes; step slowly up and down one step for 3 minutes; step vigorously up and down one step for 3 minutes; run for 3 minutes on the playground; use the jungle gym in a specific manner for 3 minutes, etc.)

After brainstorming, have students choose 4 activities and write them on the worksheet. Explain that they are to:

1. Take an at rest reading and record heart rate on chart with dot;
2. Perform 1st activity and record heart rate;
3. Rest 5 minutes and record heart rate;
4. Perform 2nd activity and record heart rate, etc. and then connect dots with lines as shown on astronaut chart.

SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Small

TIME:
60 minutes

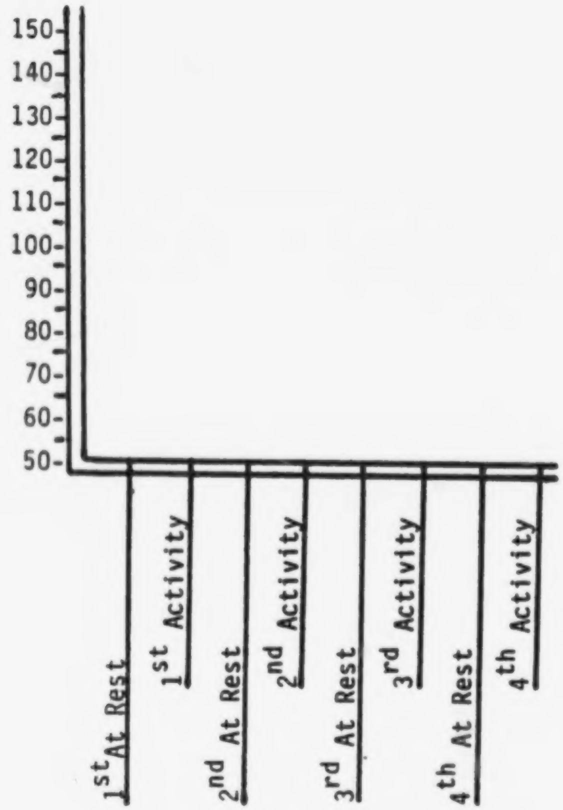
TYPE OF ACTIVITY:
Investigation

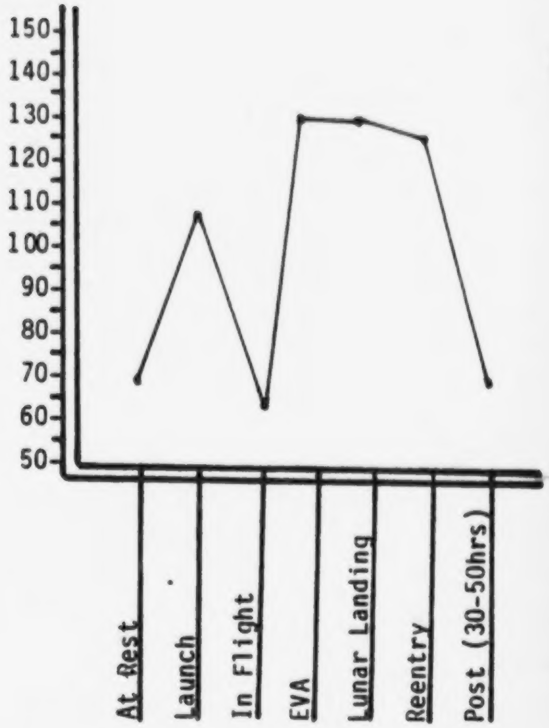
TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Heart rate
Space activity

SKILLS:
Recording data
Comparing
Graphing
Measuring

RESOURCES:
243, 254, 258,
279, 296, 297





ACTIVITIES

Activity 1______________________

____

Activity 2______________________

____

Activity 3______________________

____

Activity 4______________________

____

ASTRONAUTS	AT REST	LAUNCH
Yuri Gagarin	64	120
John Glenn	68	114
Scott Carpenter	65	96
Gordon Cooper	76	147

Note: The highest heart rate recorded in a US space flight was 180 bpm recorded by Astronaut Eugene Cernan during Gemini IX during EVA.

The heart rate of the astronauts decreased while they were weightless. Why do you think that may have happened?

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PHYSICAL FITNESS IN SPACE

Objective: To become aware of the type of exercise performed by astronauts during space flights.

Materials: Watch with second hand or stop watch. Bicycle inner tube, 20". Piece of broom handle, 8" long.

Teacher Background Information: Due to limited area in the space cabin, the activities to maintain physical fitness must be designed for cramped accomodations. Have students do some research on the importance of exercise in space and some of the ways astronauts do maintain an exercise regimen. Discuss how weightlessness affects exercising in space and why the lack of resistence in the weightless condition can lead to muscle and bone deterioration. As the students get ready to futurize on their own colony in space, this aspect of living in space must be attended to along with food, water, oxygen, etc.

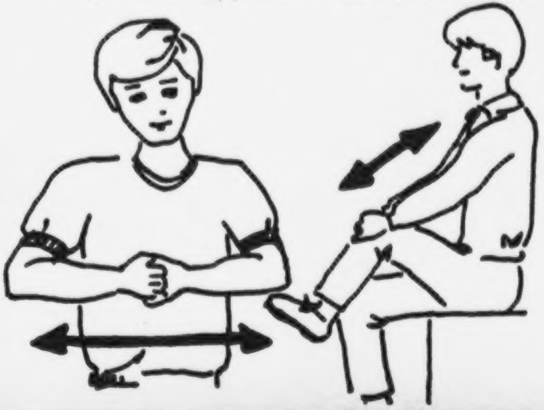
Procedure: Talk with students about isometric exercise. Ask why it is a likely candidate for the kind of exercise astronauts could do on a space ship. Give the students the examples of the isometric exercises listed here.

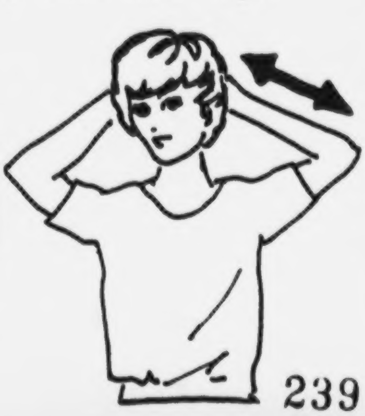
1. Grasp right hand in left hand and pull in opposite directions while hands are held together for 5 seconds, 10 seconds and 20 seconds.

2. Grasp left leg at the knee with clasped hands. Pull leg toward chest 12 times. Repeat procedure with right leg.

3. Clasp hands behind head. Pull in opposite directions.

4. In a seated position, clasp hands under legs. pull in opposite directions.





SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Large

TIME:
45 minutes

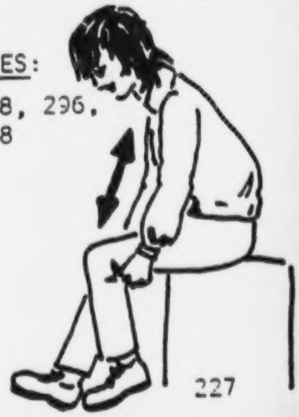
TYPE OF ACTIVITY:
Simulation

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Physical fitness
Isometrics

SKILLS:
Recording data
Inference

RESOURCES:
254, 258, 296, 297, 298



Resistance Exercise:

1. Loop-hitch the bicycle inner tube around the middle of the wooden handle and tighten securely.

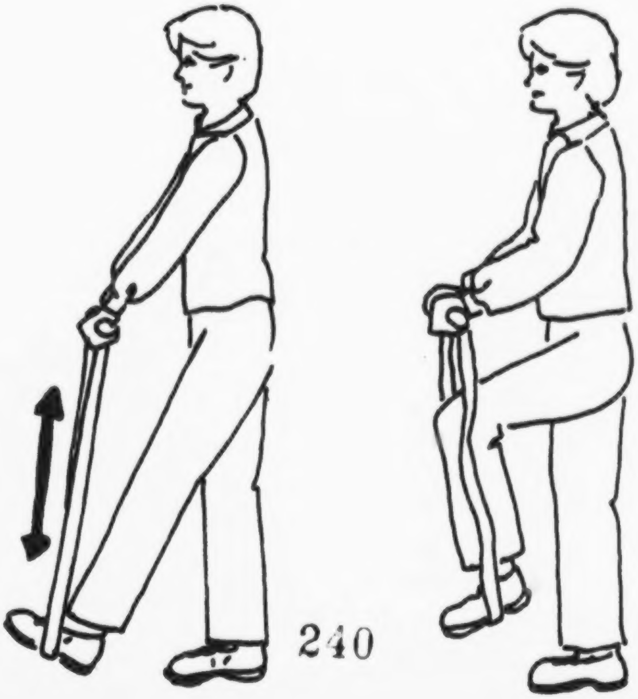
2. Count the pulse for a period of 30 seconds and record.

3. Place one foot in the open end of the loop while holding the handle with both hands.

4. Pull the loop against the foot, release, continuing this operation at the rate of one pull per 30 seconds. Change immediately to the other foot and repeat the operation.

5. At the end of the second operation, check the pulse again and record. Note the change in pulse rate and muscular feeling.

6. Discuss other ways of providing exercise in a small space that will still provide the kind of resistance to work the muscles. Brainstorm some ideas and have the students work out ways of doing them in the classroom. Have them keep records of their heart rate changes before and after doing the exercises.



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IT'S ALL RELATIVE

Objective: To provide students with some basic information on Einstein's General Theory of Relativity as it relates to time and travel; to provide students with basic idea of hyper speed.

Materials: Worksheet (See following pages). Pencils.

Teacher Background Information: Should your students have heard of some of the concepts of Einstein's General Theory of Relativity related to time and travel at the speed of light, they may use "hyperspeed" as a way of dealing with vast distance in space when doing their futurizing. In fact, we do know that travel at the speed of light would cause time to stand still. Practically, however, nothing other than light has ever been measured at the speed of light (186,000 miles per second and for various reasons it's not very likely that anything like a spaceship will be clocked at any speed close to it).

In reality, a future astronaut will have to be content with traveling at some fraction of the speed of light and no real effect on time will be noticed anyway until the astronaut begins to travel at more than 75% of the speed of light. Astronauts traveling at speeds less than this will just have to get used to aging at about the same rate as those of us left here on Earth. For example, a journey that would take five light years at 10% the speed of light would seem to take 50 years to the observer on Earth and only about three months less to the astronaut who made the trip--hardly anything for actuaries to get worked up about.

Present technology would allow us to travel at perhaps 25 to 30 percent of the speed of light. Even given new technologies, there are still problems to work out. For one thing, as energy is added to an object to accelerate it, its mass increases also in the form of energy to go faster as it goes faster. The end result is, it would take forever to reach the speed of light.

Some interesting possibilities exist, however, should we be able to achieve even 95% of the speed of light. Take a look at this:

An astronaut who is 30 years old has a child who is 10. The astronaut leaves for a trip to the "Tronolog" Galaxy about 12 light years away. Allowing for time to accelerate to 95% of the speed of light and to slow down coming back, the trip will seem to take about 30 years

(continued)

SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Large

TIME:
45 minutes

TYPE OF ACTIVITY:
Discussion

TEACHING STRATEGY:
Expository

CONCEPTS:
Relativity
Hyper-speed

SKILLS:
Inference
Hypothesizing

RESOURCES:
262

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*One light year=the distance light would travel in one earth year or 5, 849, 600,000 miles.

to the child left back on earth, so the child will be an adult of 40 at that time. The astronaut parent will have traveled for what seems to be about 10 years making him or her 40 when the ship returns to Earth. Now parent and child are the same age.

Let the students have some fun with this. Though we may never flit around space like Captain Kirk and Spock or make time stand still or time warp into galaxies on the other side of black holes, some fascinating situations could occur even at the fractions of the speed of light we may eventually achieve.

Procedure: Give each student a copy of the "Thanks to Mr. Einstein" sheet and do the first problem with them. Assume for the purposes of the worksheet, that we have solved the problems of space dust sand papering the nose off the spacecraft and any other troublesome aspects of hyperspeed travel. When they have finished with the worksheet, ask them to make up problems for other students to solve.

KEY:

1. a.) twelve and a half b.) in the 7th or 8th grade, assuming he/she's typical c.) six and in first grade, probably (5 years x 2.294 = the age of the stay at home + 1 year because that's what s/he was already when the neighbors left.) The traveling child has aged the 5 space years he/she was gone + the 1 year before s/he left making the child 6 years old.

2. a.) 4 years, 4 months

3. The statute of limitations would have run out.

4. a.) 72 years and 6 months b.) approximately 7 years c.) The commander was 36 years old.

5. If he got on a spaceship for two years at 99% the speed of light, he would be 36 when he returned. His fiance would have aged 14 years during those two years in space and would also be 36 years old. (But probably not real thrilled with his solution.)

6. King Tut (1371 BC)

THANKS TO MR. EINSTEIN.....

we know that:

While one year passes in Space traveling at this percentage of the speed of light	this many years pass on Earth
90%	2.294
95%	3.202
99%	7.089
99.9%	22.361
99.999%	223.607
100%	Infinite

Given that information, try the following:

1. Two neighboring families each had a child born on the same day one year ago. One family leaves on a space trip at 90% the speed of light and is gone for 5 space years. The second family stays home. Questions: How old would the child who stayed at home be, when the traveling family returns? What grade would he be in? How old and in what grade would the traveling child be?

2. If you wanted to beat the record for oldest living person on Earth, you would have to beat Methuselah's record of 969 years. How long would it take you at 99.999% the speed of light to break that record?

3. Dapper Dan, an infamous and clever jewel thief, was apprehended by Detective Bullhorn Blodgett in Cleveland. "I've got all the evidence I need to convict you," Blodgett told the thief and he was right. Dapper Dan pretended to give up without a fight, but just as Blodgett was about to put the handcuffs on the culprit, Dan broke loose and escaped to a waiting spaceship he had arranged for in case something like this ever happened. The spaceship was programmed to travel at 99% the speed of light and to be gone for one space year. Why wasn't Dapper Dan worried about being taken into custody when he returned?

4. A pair of identical twins became astronauts. The first twin was made commander of a spaceship that traveled at 99% the speed of light. The other twin was given a position on Earth as a communications expert. When the twins were 30 years old, the first twin left Earth in the spaceship and traveled at 99% the speed of light for 6 space years. How old was the twin on Earth when her sister returned? If she had retired at 65, how long had she been retired? How old was her sister, the spaceship commander?

5. Bill was 34 and Carolyn was 22 when they met, fell in love and decided to get married. When the happy couple told Carolyn's parents, her father shouted, "Absolutely not! You're much too old for our little Carolyn and you shall never have my permission to marry."

Carolyn cried a lot but Bill was amazingly calm about the whole thing. "Don't worry,dear," he said. "I'll be able to get your father's permission to marry you

(Con't)

in two years because we'll both be the same age by then." How could he make such a promise?

6. If E.T. had been traveling at 99.999% the speed of light 15 space years ago and had visited Egypt, who would he have found ruling as King of Egypt?

$$E = mc^2$$

93

PAPER STARSHIPS

Objective: To give students opportunity to construct a model of starships as motivation for futurizing activity; to learn about parts of spacecraft and configuration.

Materials: Glue. Scissors. Paper clips. Coloring pens or crayons. Rulers. Paper. Copy of model to cut out (See following page.).

Procedure: Talk with students about living in space and what sort of environment people would have to have. Dream a bit. Imagine enormous starships with people living on board, perhaps never having known any other environment. This model is a relatively simple one and the students should be encouraged to imagine it as an enclosed environment with all the physical and emotional needs of those on board looked after. After talking about starships and such, give each student a copy of the model to cut out and glue together. The directions are given but here are a few helpful hints:

1. Have students look over the whole set of cut-outs and directions before they start in, so they can get an idea of what the craft will look like. Many children will have NO problem; a few may have some spatial difficulty and will find themselves confused if they cut out the pieces before they've had a chance to visualize it in their minds.
2. Practice launching the crafts after they have finished. Don't throw the model. Use a forward glide stroke and aim in a horizontal flight path.
3. The craft will require one or two paper clips to be attached to the front of the nacelles for ballast. Test for need.

Extension: Have students design and make their own starship model. Color it, fly it and write a short poem about it. Display starships and poems in room. (They'll look super on a black background)

SUBJECT:
Science

GRADE:
Sixth

GROUP SIZE:
Individual

TIME:
45 minutes

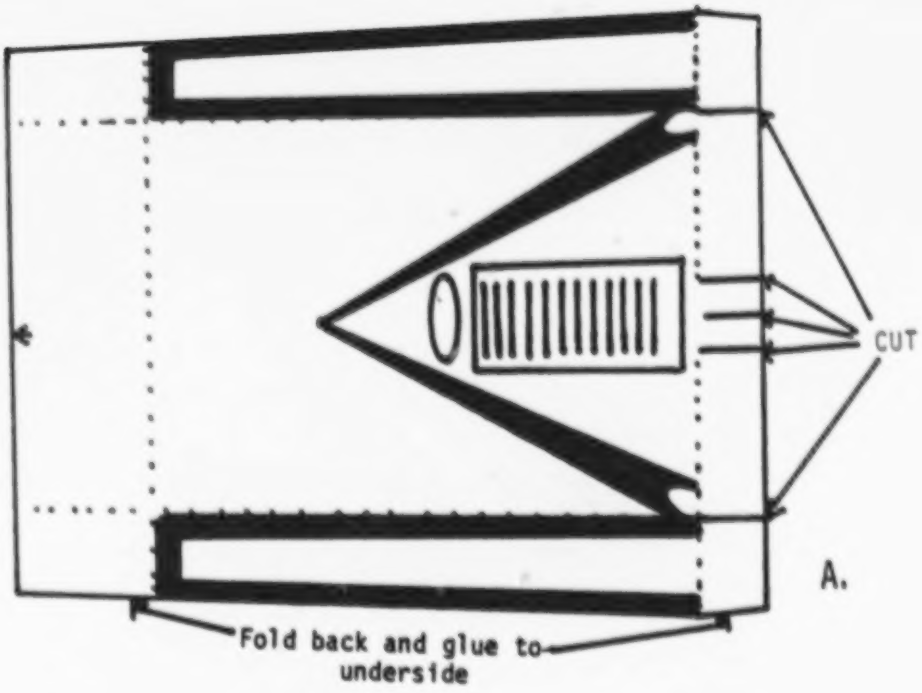
TYPE OF ACTIVITY:
Modeling

TEACHING STRATEGY:
Guided Discovery

CONCEPTS:
Starship
Model
Configuration

SKILLS:
Construction
Design
Futurizing

RESOURCES:
189, 194, 197, 236



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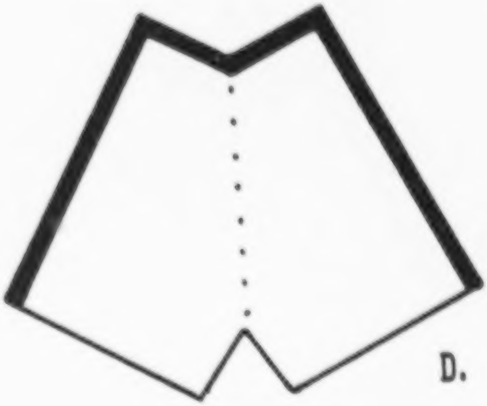

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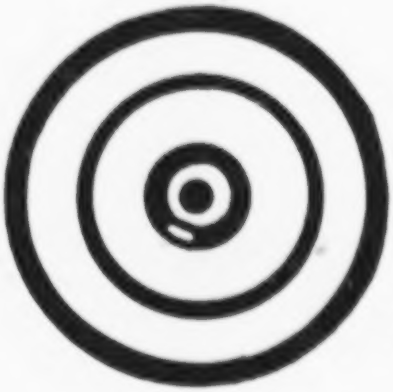

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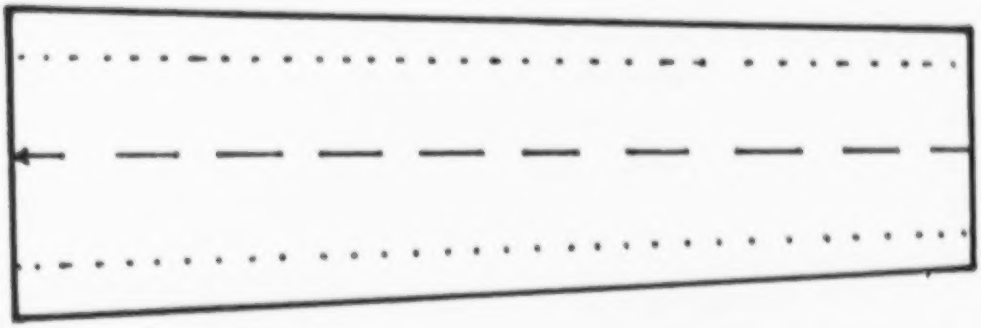
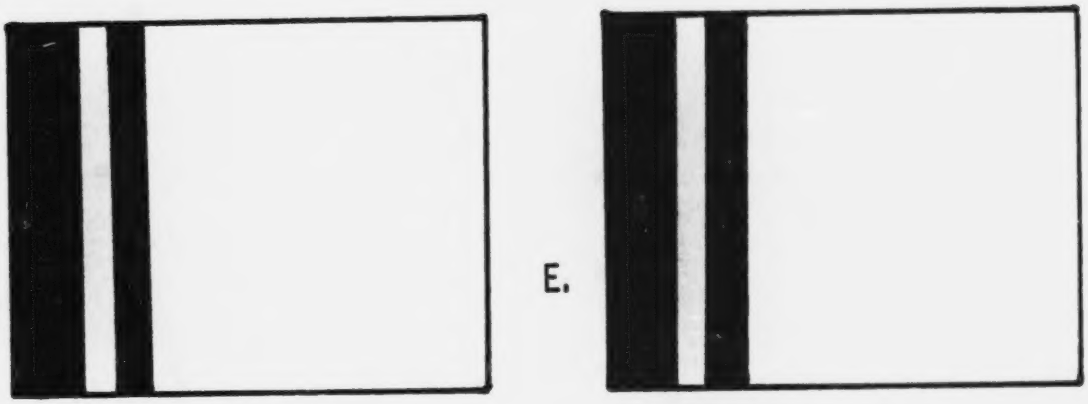
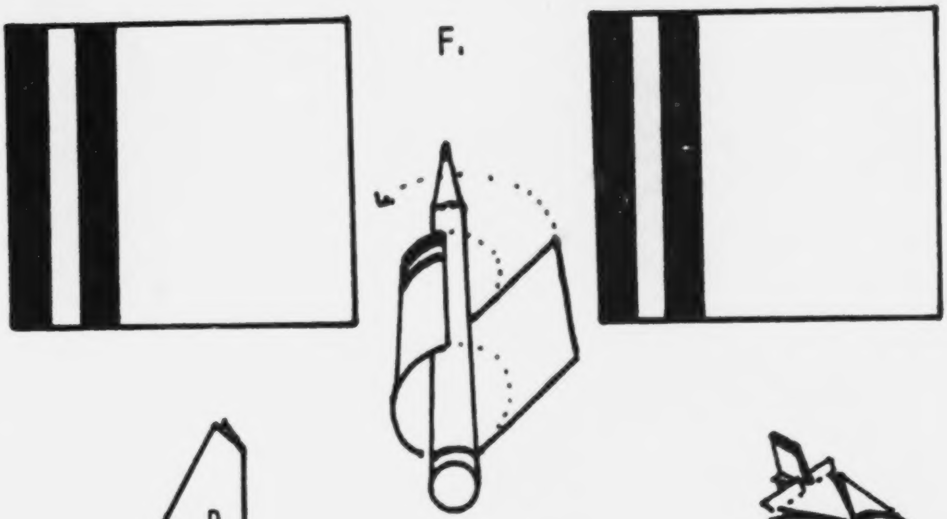


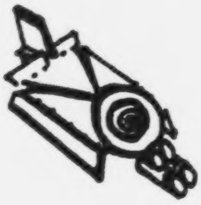
B.

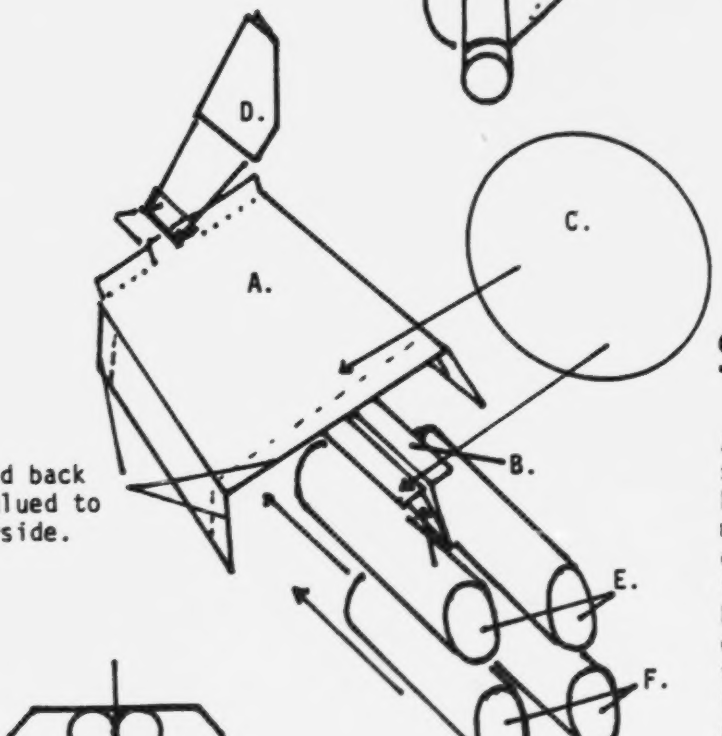
..........Mountain Fold Λ

— — —Valley Fold V









Folded back and glued to underside.

STT-1

After cutting out all the sections, build all the parts before attaching them to the main body of the ship. Attach center brace (B) to Wing surface (A). Glue tail (D) into B at rear. Attach larger nacelles (E) to B in front and then attach smaller nacelles (F) to underside of E's. Last, glue C over exposed top of B and part of A.

94

DREAMS YOU DARE TO DREAM....

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

2 - 3 weeks

TYPE OF ACTIVITY:

Student Investigation

TEACHING STRATEGY:

Open Discovery

CONCEPTS:

Space Communities
Space travel
Space fantasies
Space stations

SKILLS:

Predicting
Collecting and interpreting data
Research skills
Fantasizing
Modeling

RESOURCES:

207, 212-214, 219, 234, 238-240, 265, 281, 293, 297

Objectives: To help students make predictions about establishing communities in space; to construct a model of a space community.

Teacher Background Information: Introduce this unit on futurizing after the students have had the opportunity to do several other aerospace activities and have identified, discussed and researched any problem areas of traveling and living in space. This background should enable them to make some predictions about the future founded on sound principles rather than simply repeating "far out" ideas gleaned from TV or the movies. (It should help them evaluate better the things they see in those movies, as well.)

Encourage the students to dream, however. Talk about the usefulness of taking time to daydream - time absolutely necessary to the creative process. Talk with them about creativity as a process that breaks down mind set and allows us to come up with things here-to-fore unknown. Explain, emphatically, that creativity is a part of all of us - not only the painter and the piano player.

You might like to do some activities on mind set or on habits and discuss how difficult they can be to change. (One of the easiest ways to show that is to bring in homemade bread or bisquits tinted as green as you can get them topped with red or blue butter. What fun to eat after the initial "yuchs" are over.) Talk about how we will have to change as our technology changes, as our resources deplete, as our knowledge of society's physical and emotional needs increases, etc. Talk about the responsibility of making wise decisions based on the best information we have at any given time using our sharpest critical thinking skills; discuss our equal duty to modify our decisions when new "best" information is presented.

It has always been true that we teach best when we teach how to learn - it is getting truer every day as changes come furiously one upon another. This activity is designed to aid in this endeavor

Procedure: Explain to the students what the theme of the activity is and discuss the rationale for doing it. Ask why they think it is important to do this kind of

(Con't)

activity. Let them know why you think it is valuable. Decide on the length of the activity and explain that others (decide who they will be) will be coming in to share what the groups have done.

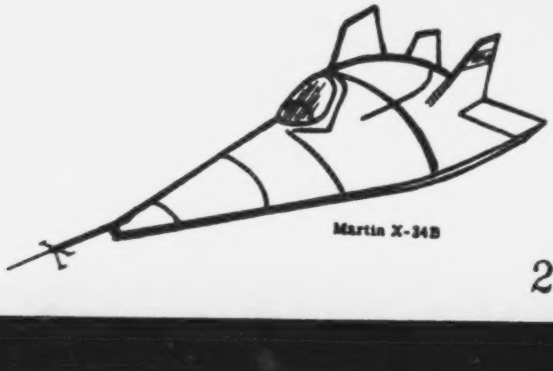
Brainstorm with the students as many possible topics related to living in a space community as you can. Give the students time to generate lots of ideas without any judgment or criticism. Don't worry about order or sequence or how bizarre some ideas may be and do not let students do it either. The goal here is to get as many ideas on the blackboard as possible and to evaluate and organize later.

(Included on the following page, is just the beginning of a brainstorming session on the topic. Look it over but do not use it as the beginning and end of the brainstorming session. There is so much more that will come up and your students must have the opportunity to do their own thinking and dreaming.)

Once you and your students have brainstormed all the areas related to living in a space community, have the students form their groups and organize the data in a way that makes sense for them. For example, if one group is going to work on a model of a mining station on the Moon, they may not be concerned with schooling or population control or agriculture but they may be very concerned with transportation or government restrictions. A group that is working on a community of people who have left Earth to find a whole new complex society will have to organize several categories to look into.

After the groups have had sufficient time to order their search, provide library time, books, pamphlets and magazines, construction time, talk time, etc. Set aside time specifically for working on the project over 2 or 3 weeks and encourage interacting with other groups as the activity progresses.

When the projects are finished, have each group present its space community. Give students the opportunity to ask questions and to share what they have learned. Have the students write about the experience or their community in a poem, short story or expression of their choice after the presentations are over.



Martin X-24B

Gravity

Weightlessness

Other life on it

Architecture

Schooling

Food

Government

Rules/Restrictions

Size

Population control

History

Health care

Who gets to go?

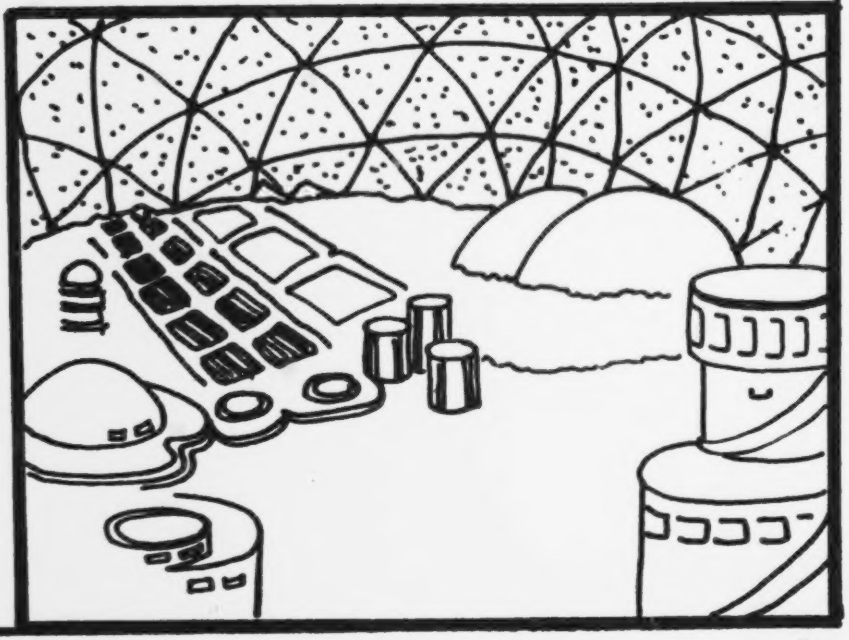
Sports

SPACE COMMUNITIES

Getting there

Recreation

Garbage



Sleeping

Industry

Agriculture

Where is it?

Energy Sources

Animals

Mining

Movies

Jobs

95

CAREERS IN AVIATION AND AEROSPACE

Objective: To have students gather and share aerospace career information; to encourage learning about oneself in relation to career choices.

Materials: Books, magazines, pamphlets, etc. on aerospace careers. MOIS computer program if your school or library has access. "The Party" worksheet (Following) for each student. Names of resource people: counselors, librarians, local pilots, airport personnel, aircraft personnel, etc. whom you are aware of.

Procedure: Begin with general discussion of careers in aerospace. Talk about the need to know:

1. what kind of jobs are available
2. what education is required
3. what kind of work is actually performed on the job
4. what type of personality best fits various jobs
5. what type of personality individual student has.

Ask how they think they might go about doing this kind of search. Talk about possibilities like reading, interviewing, writing for information, visiting facilities, for example. Talk about personality inventories as indicators of personality types. Start with the one here.

Hand out "The Party" exercise and read through the 6 categories, making sure students understand the vocabulary. Read through the directions to be sure students know what to do and then do the exercise.

After students have finished, have them get together in small groups to brainstorm some possible aerospace jobs that they think fit the various categories. For example: "R" might include engineer or jet engine mechanic; "I" might be physicist or astronaut; "C" could be an airport comptroller or a computer programmer; "A" might be airport architect or interior designer for airport terminals; "E" might be an airport manager or a tax lawyer for an airlines and "S" could be a flight attendent or public relations person. (If you have any difficulty categorizing them, you can look them up in John Holland's book, Making Vocational Choices: a theory of careers. You can find copies at the library or order it directly from Prentice-Hall, Englewood Cliffs, NJ 07632. This party exercise comes from his work, as well.)

After small groups are done, meet in a large group

(Con't)

SUBJECT:

Science

GRADE:

Sixth

GROUP SIZE:

Small

TIME:

4- 45 minute periods

TYPE OF ACTIVITY:

Student Search

TEACHING STRATEGY:

Guided Discovery

CONCEPTS:

Aerospace careers
Information
Search
Personality type

SKILLS:

Searching
Organizing data
Categorizing

RESOURCES:

NASA Publications Catalog

to get a more expanded list of jobs. Then have the students do some research on aerospace careers and add to their individual list. Meet again in large group and go over the additions. Now, using the results of the exercise as a guide, have students choose a specific occupation to investigate. Try for as many different choices as possible and set a time for finished reports. Proceed with search.

Written report format:

A. Introduction

1. What I knew before I started (or thought I did)
2. Why I chose this occupation to investigate

B. Body

1. The things I read and what I learned....
2. The people I talked to and what I learned....
3. The places I visited and what I learned....

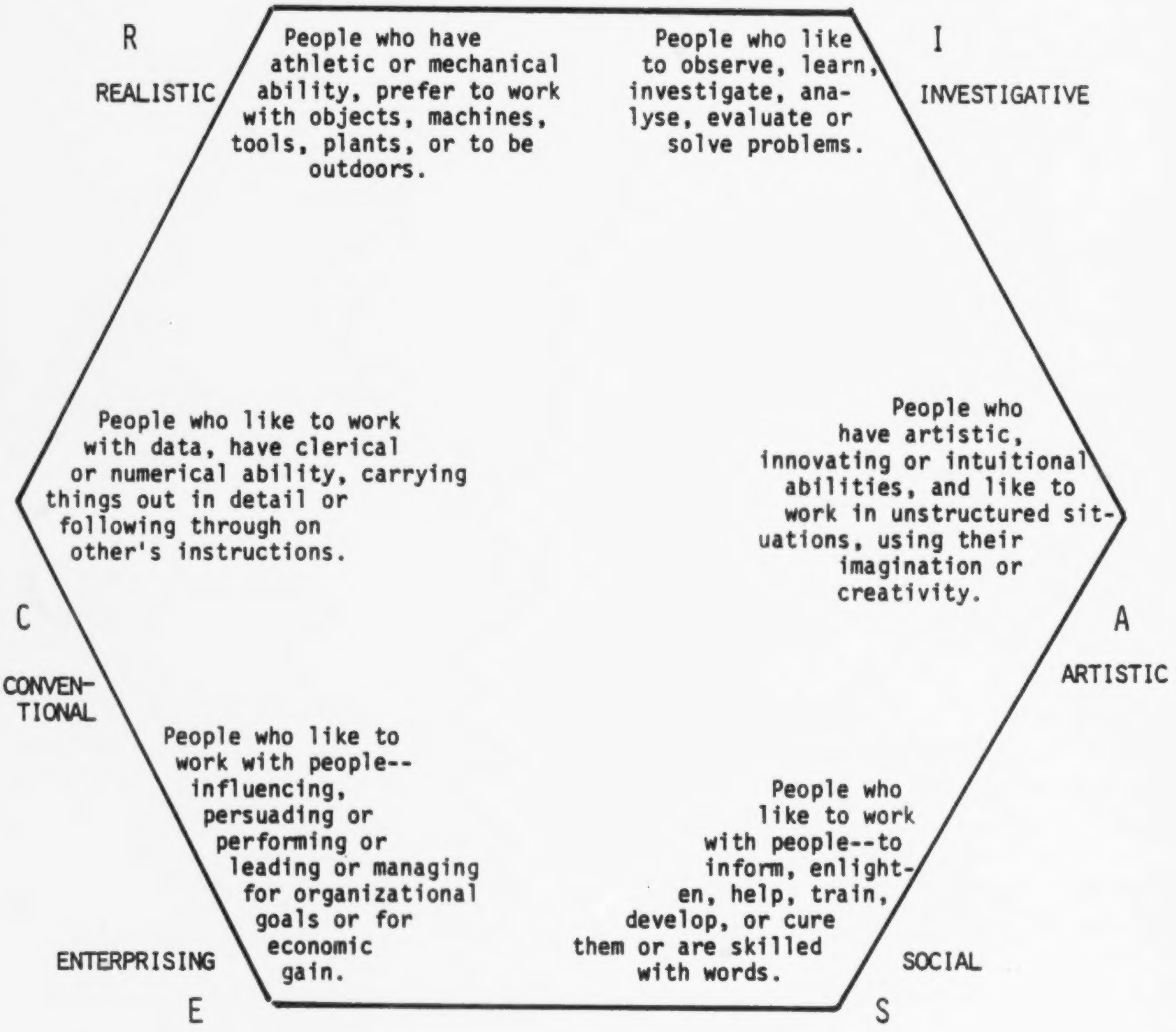
The body can be organized as above or in chronological order starting with the first thing the student did. Chronological order does allow for getting started on writing the paper before all the investigation is done. It is VERY important that the students know that their feelings about the search and what they found, are also important to the paper. This is not an objective search and they ought not to pretend it is. The paper should be written in their voice to their fellow students and should avoid what Ken Macrorie calls "Engfish." That's pretentious language or dishonest writing and Macrorie has devised this "I-Search" concept to replace some of the dishonest "research" writing done by school students across the country. The point is, this is their search or, at least, it ought to be and they should have the opportunity to present it honestly.

C. Conclusion

1. A summary of what I learned about aerospace careers and about myself
2. What I still need to find out (if applicable)

Have students share their findings with a brief oral presentation of some important or interesting thing they discovered in their search and make each written report available to other students to read.

THE PARTY



R

REALISTIC

People who have athletic or mechanical ability, prefer to work with objects, machines, tools, plants, or to be outdoors.

I

INVESTIGATIVE

People who like to observe, learn, investigate, analyse, evaluate or solve problems.

People who like to work with data, have clerical or numerical ability, carrying things out in detail or following through on other's instructions.

People who have artistic, innovating or intuitional abilities, and like to work in unstructured situations, using their imagination or creativity.

C

CONVENTIONAL

A

ARTISTIC

People who like to work with people--influencing, persuading or performing or leading or managing for organizational goals or for economic gain.

People who like to work with people--to inform, enlighten, help, train, develop, or cure them or are skilled with words.

ENTERPRISING

E

SOCIAL

S

1.

At the party which corner of the room would you instinctively be drawn to, as the group of people you would most enjoy being with for the longest time? Leave aside any questions of shyness, or whether you would have to talk with them. Write the letter for that corner here. ________

2.

After fifteen minutes, everyone in the corner you have chosen, leaves for another party, except you. Of the groups that still remain now, which corner or group would you be most drawn to, as the people you would most enjoy being with for the longest time? Write that letter here. ____________

Youth in Aviation

AVIATION EXPLORING

Exploring is the young-adult division of the Boy Scouts of America. Explorers are young men and women aged 14 through 20 who join Explorer posts organized by schools, churches, businesses, and community organizations, in cooperation with their local BSA council. These posts specialize in a variety of career and recreational programs designed to provide career service, outdoor, social, citizenship, and fitness activities.

A Special Program

Aviation Exploring is one of the speciality programs within Exploring. It's designed for young men and women interested in pursuing vocations or avocations in aviation, aerospace or related areas. It is designed as a hands-on experience for youth, bringing them into association with adults, facilities and activities related to aviation. Through Aviation Exploring, young people ''try on'' different careers and lifestyles under informal but expert guidance. Each post designs its own program by matching the interest of its members with the program and resources available. Posts specialize in such fields as flight training, mechanics, flight attendants, airport management, customer relations, ground support, ballooning, soaring, avionics, and more. The purposes of the organization and the BSA are best served when a well-rounded program is planned through service, citizenship, and outdoor activities. This planning provides post members an exciting and worthwhile program leading to personal fitness, citizenship training and character development.

Organizing A Post

The founders of the organization meet with representatives of the local BSA council to discuss starting an Explorer post. The organization agrees to recruit adult volunteer leaders, develop a list of program ideas and provide meeting facilities. The BSA council provides organizational help, leader training, program support, literature, liability insurance, activity planning and ongoing volunteer and staff service.

Joining a Post

If you are a young man or woman between the ages of 14-21, and at least a ninth grade student, you are eligible for membership in Exploring. Prior experience in Scouting or in aviation is not required.

For More Information

Contact your local
Boy Scout of America Council

CIVIL AIR PATROL

CAP develops youth interest in aviation and it helps mold our aerospace leaders of the future. It provides cadet members an opportunity to learn the basis of aerodynamics, navigation, aircraft and rocket propulsion systems, aviation history, and the impact of aviation on society. Equally important are the experiences cadets receive in leadership training, moral leadership sessions, and physical conditioning.

Activities, which range from the local to the international level, are the heart of the program. These activities include first aid and survival training, radio communication, and actual flight in modern aircraft.

Being a CAP cadet is truly exciting. Travel, adventure, study...all are part of the life of a cadet. In the United States each summer CAP cadets may spend a week at an Air Force base, live the life of a regular airman, use the same quarters, food service and recreational facilities as Air Force personnel...fly orientation flights in Air Force aircraft, study maintenance of engines, radar, radio, and related areas.

International Exchange

CAP's International Air Cadet Exchange is one of the most sought-after of all the cadet special activities. The exchange involves a three-week trip to one of more than 20 foreign countries. The cadets visit in the homes of host families and thrill to visits to historical shrines of the world.

Scholarships

Civil Air Patrol offers scholarships in .. engineering, languages, airport management, physics, aeronautics and aerospace medicine. Outright educational grants are also offered. Every cadet may compete for these scholarships. Study grants are available for youth not planning to attend a four-year college or university course.

Cadet Program

The CAP aviation education program for youth is now available in 89 Michigan communities. It offers a wide variety of flight, academic, career exploratory and other related experiences. Special summer courses, flight encampments, and visits to aviation facilities are made available on a competitive selection basis.

Aerospace Education

The Michigan Wing has continued to play a major role in providing information and assistance to educators in aviation and aerospace education matters. Close liaison and coordination is maintained with the many state and national organizations having an active interest in aviation/aerospace education.

For More Information

Michigan Wing CAP
30712 Michigan Avenue
Building A
Westland, MI 48184
(313) 721-6210

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Moisture and Precipitation in the Air

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137. Satellite Photo-Atlas of the United States. Photo Geographic International. Ward Ritche Press, 1975.
138. Wilson, Don. Our Mysterious Spaceship Moon. Dell Pub., 1975.

STUDENT BOOKS

139. Branley, Franklin. A Book of Mars for You. Crowell Co., 1968.
140. Fodor,R.V. Meteorites, Stones From the Sky. Mead, 1976.
141. Pieces of Another World: Story of Moon Rocks.Crowell Co., 1972.
142. Highland, Harold. The How and Why Wonder Book of Planets and Interplanetary Travel. Grossett, 1970.
143. Knight, David. Let's Find Out About The Earth. Watts, 1975.

144. Asimov,Isaac. Alpha Centauri, The Nearest Star. Lee & Shepard,1976.

145. Asimov, Isaac. Saturn and Beyond. Lee & Shepard, 1979.

146. Asimov, Isaac. To the Ends of the Universe. Walker, 1976.

147. Branley, Franklyn. A Book of Planet Earth for You. Crowell, 1975.

148. Branley, Franklyn. Black Holes, White Dwarfs and Superstars. Crowell, 1976.

149. Branley, Franklyn. Mars, Planet Number Four.Crowell, 1976.

150. Chester, Michael. Let's Go to the Moon. Putnam, 1975.

151. Kerrod, Robin. The Universe. Watts. 1976.

152. Kuskin, Karla. A Space Story. Harper & Row, 1978.

153. Lefkowitz,R.J. Forces in the Earth: A Book About Gravity and Magnetism. Parents' Magazine Press, 1976.

154. Mayall,R. Newton. The Sky Observers Guide: A Handbook for Amateur Astronomers. Golden Press, 1978.

155. Maynard, Christopher. Planet Earth. Watts, 1976.

156. Maynard, Christopher. Young Scientists Book of Stars and Planets. EMC Corp.,1978.

157. McGowen, Tom. Album of Astronomy. Rand McNally, 1979.

158. Mitton, J. & S. Concise Book of Astronomy. Prentice Hall,1979.

159. Morris, Dean. The Universe. Raintree Childrens Press, 1978.

160. Nusssbaum, Heda,ed. Charlie Brown's Second Super Book About Earth and Space. Random House, 1977.

161. Rey, H.A. Find the Constellations. Houghton Mifflin, 1976.

162. Wicks, Keith. Stars and Planets. Warwick, 1978.

163. Wheat,Janis K. Let's Go To The Moon. National Geographic Sosiety,1978.

164. Yerian, C & M. Projects: Earth and Sky. Childrens Press, 1975.

165. Shapp, Martha & Charles. Let's Find Out About The Moon. Watts, 1976.

INEXPENSIVE PUBLICATIONS

166. Our Prodigal Sun. EP-118, NASA

167. Exploration of the Solar System. EP-122, NASA

168. Comparing the Planets. NF-58, NASA

169. Teacher's Guide for NF-58

170. The World of Science Kits, Kit #1, Earth and the Universe. Covers Earth, Stars and Planets, Weather and Climate. Young Readers Press, $15.80.

(Many other publications too numerous to list)
SEE NASA PUBLICATIONS LIST

FILMS

171. Journey Into Light. (Story of the Kit Peak National Observatory) Kitt Peak, Tucson, AZ.

172. Earth - Sun Relationship. HQ 235- NASA.

173. The Earth: Its Atmosphere. Coronet.

174. Universe. NASA.

175. Universe and I. (Upper grades) Agency for Instructional Television.

176. Our Solar System. (Teaches names and order of planets) NASA.

177. The Solar System. (A trip through the planets) Agency for Instuctional Television.

178. Who's Out There? NASA.

(Many other films too numerous to list)
SEE NASA FILMS LIST

FILMSTRIPS AND CASSETTES

179. Martin, Bill. Moon Cycle, a Little Nature Book to be Read Aloud. Encyclopedia Britannica Educational Corp., 1975.(Primary).

180. Secrets of the Universe. Society for Visual Education, 1976. A series of 5 filmstrips and booklets for grades 1-5.
Topics:
- Earth
- Sun
- Moon
- Solar System
- Stars

ROCKETS AND MISSILES

TEACHER BOOKS

181. Gunston, Bill. The Illustrated Encyclopedia of Rockets and Missiles. Cresent Books, 1979,c1978.
182. David, Heather. Werner Von Braun. Putnam, 1967.
183. Stine, Harry. The Model Rocketry Manual.Arco,1975.

STUDENT BOOKS

184. Baker, David. Rockets. Crown, 1978.
185. Bergaust,Eric. Rocket Power. G.P. Putnam Sons,
186. Branley, Franklyn. Rockets and Satellites.Crowell,1970.
187. Daugherty,Charles. Robert Goddard,Trail Blazer to the Stars. Macmillan, 1974.
188. Edmonds, I. Jet and Rocket Engines: How They Work.Putnam,1973.
189. Edmonson,Harold,ed. Famous Spaceships of Fact and Fantasy: And How to Model Them. Kalmbach Publishers, 1979.
190. Gatland, Kenneth. Missiles and Rockets.Macmillan, 1975.
191. Holder, William. Saturn V: The Moon Rocket.Messner,1970.
192. Rosenfeld, Sam. Ask Me a Question About Rockets, Satellites and Spacestations.Harvey House, 1971.
193. Tannanbaum, Harold. We Read About Rockets.Webster Division, McGraw-Hill, 1962.

FREE AND INEXPENSIVE MATERIALS

194. Educator Packet. # 1452 , Estes Industries. $1.00. Estes has many educational materials and models. Write for current catalog. Estes, Penrose, Colorado 81240.
195. Information on lesson plans, bibliographies,books,etc. AVI Astroport.
196. Launch Vehicles. NASA FACTS , NASA.
197. Model Rocket Catalog. AVI Astroport.

FILMS

198. About Our Missiles. U.S. Air Force.
199. Common Carrier for Space - Titan III. U.S. Air Force.
200. Research Project X-15 HQ. NASA.
201. Road to the Stars.(History of the rocket and its uses) USAF.
202. Rocket Launches From Cape Kennedy. Apollo Project, NASA.
203. The Missile Navy. Sperry Univac.
204. X-15. USAF.

SATELLITES, SPACECRAFT AND SPACE TRAVEL

TEACHER BOOKS

205. Baker, David. Space Shuttle. Crown, 1979.
206. Berman, Arthur. Space Flight. Anchor/Doubleday, 1979.
207. Brand, Stewart. Space Colonies. Whole Earth Catalog,1977.
208. Burshall,W.J.,et al. Space Shuttle Missions of the '80's. American Astronautical Society, 1977.
209. Calder, Nigel.Spaceships of the Mind. Viking Press, 1978.
210. Cromie, William, Skylab: The Story of Man's First Station in Space. David McKay, 1976.
211. Dickson, Paul. Out of This World. Delacorte, 1977.
212. Gilfillan, Edward. Migration to the Stars. Distributed by McKay, 1975.
213. Glenn. Jerome K. Space Trek: The Endless Migration.Stackpole, 1978.
214. Golden, Frederic. Colonies in Space. Harcourt Brace Jov., 1977.
215. Grey, Jerry. Enterprise. Morrow, 1979.
216. Grey, Jerry. Space: A Resource for Earth. American Institute of Aeronautics and Astronautics, 1978.
217. Gurney, Gene and Clare. The Launching of Sputnik, October 4, 1957: The Space Age Begins.Watts, 1975.

218. Hapgood, Fred. Space Shots: An Album of the Universe. Times Books, 1979.

219. Heppenheimer, T.A. Colonies in Space. Stackpole, 1977.

220. Johnson, Francis. International Congress on Space Benefits. American Astronautical Society. Univelt, 1975

221. Kaplan,Marshall.Space Shuttle; America's Wings to the Future. Aero, 1979.

222. Levine, Arthur. The Future of the U.S. Space Program. Praeger, 1975.

223. Moore, Patrick. The Next Fifty Years in Space. Taplinger, 1976.

224. Magnant, Robert. Domestic Satellite. Westview, 1977.

225. Nicolson, Ian. Road to the Stars. New American Library,1979.

226. Pacilio, James. Discovering Aerospace. Children's Press, 1965.

227. Pouquet, Jean. Earth Science in the Age of the Satellite.Reidel,1975.

228. Powers, Robert. Planetary Encounters: The Future of Unmanned Space Flight. Stackpole, 1978.

229. Powers, Robert. Shuttle: The Worlds First Space Ship. Stackpole,1979.

230. A New Era of Space Transportation. International Astronautical Congress. Pergamon Press, 1977.

231. The Impact of Space Science on Mankind.Proceedings of the 31st. Nobel Symposium. Plenum Press, 1977.

232. Space Transportation Systems: 1980-2000.American Institute of Aeronautics and Astronautics, 1979.

233. Richason, Benjamin. Introduction to Remote Sensing of the Environment.Kendall/ Hunt, 1978.

234. Tross, Carl. Future Space Activities. American Astronautics Society, 1977.

235. von Braun, Werner, and Frederick Ordway. New Worlds: Discoveries from Our Solar System. Doubleday, 1979.

STUDENT BOOKS

236. Ames, Lee. Draw 50 Airplanes, Aircraft & Spacecraft. Doubleday,1977.

237. Asimov,Isaac. ABC's of Space. Walker and Co., 1969.

238. Bergaust, Erik. *Colonizing Space*.Putnam, 1978.

239. Bergaust, Erik. *Colonizing the Planets.* Putnam, 1976.

240. Bergaust, Erik. *The Next 50 Years on the Moon*.Putnam, 1974.

241. Chester, Michael. *Let's Go on a Space Shuttle*. Putnam, 1977.

242. Ciupik, Larry. *Space Machines*.Raintree, 1979.

243. Cobb, Vicki. *Supersuits.* Lippincott, 1975.

244. *Enterprise and Beyond: The Story of the Space Shuttle.* Collins, 1979.

245. Collins, Michael. *Flying to the Moon and Other Strange Places.* Farrar, 1976.

246. Coombs, Charles. *Passage to Space; the Shuttle Transportation System*. Morrow, 1979.

247. Couper, Heather and Nigel Henbest. *Space Frontiers*. Viking,1978.

248. *Robots in the Sky, Explorers of Our Solar System*. Golden Gate Junior Books, 1972.

249. Engelbrektson, Sune and Peter Greenleaf. *Let's Explore Outer Space.* Arco, 1975.

250. Frisky, Margaret. *The True Book of the Moonwalk Adventure.* Children's Press, 1970.

251. Gurney, Gene. *Space Technology Spinoffs.* Watts, 1979.

252. Hendrikson,Walter. *Manned Spacecraft to Mars and Venus: How They Work*.Putnam, 1975.

253. Kerrod, Robert. *See Inside A Space Station*. Warwick,1979.

254. Knight, David. *American Astronauts and Spacecraft*.1976.

255. Knight, David. Colonies in Orbit; *The Coming Age of Human Settlements in Space*.Morrow, 1977.

256. Kohn, Bernice. *Communications Satellites: Message Centers in Space*. Four Winds, 1975.

257. Langseth, Marcus and Lillian. *Apollo Moon Rocks*.Coward,McCann and Geoghegan, 1972.

258. Moche,Dinah. *The Astronauts*.1978.

259. Morris, Dean. *Into Space*. Raintree Children's Books, 1978.

260. Pope, Billy. *Your World: Let's Visit a Spaceship*.Taylor, 1971.

261. Stine, G. Harry. *Shuttle Into Space- A Ride in America's Space Transportation System.* 1978.

262. Tauber, Gerald. *Albert Einstein's Theory of General Relativity*. Crown, 1978.

263. Taylor, L.B. Space Shuttle. Crowell, 1979.

264. The Young Scientist Book of Spaceflight; Discovering Space With Projects and Diagrams. EMC Corp., 1978.

FREE AND INEXPENSIVE PUBLICATIONS

265. Living in Space. NF-27 NASA.

266. Space Shuttle. NF-44. (wall chart) NASA.

267. Exploring The Moon and The Planets. EP-52 NASA.

268. Putting Satellites to Work. EP-53 NASA.

269. Apollo Soyuz Test Project. NF-51 NASA.

270. Man in Space. EP-57 NASA.

271. "In This Decade..." Mission to the Moon. EP-71 NASA.

272. Planetary Exploration. EP-82 NASA.

273. Satellites at Work. EP-84 NASA.

274. Space Shuttle. EP-96 NASA.

275. Apollo (commemorative book) EP-100 NASA.

276. Aboard the Space Shuttle. EP-169 NASA.

277. NASA Pictures - See NASA Publications List.

FILMS

278. Why Space? USAF.

279. Wonders of Weightlessness. USAF.

280. The Eagle Has Landed. USAF.

281. Space Navigation. USAF.

282. Debrief: Apollo 8. NASA (Nasa has whole series on Apollo- See Nasa Film Catalog).

283. Eagle Has Landed; The Flight of Apollo 11. NASA.

284. The Time of Apollo. NASA.

285. Apollo - Soyuz. NASA.

286. The Flight of Faith 7. (the last Mercury flight) NASA.

287. Legacy of Gemini. NASA.

288. Space in the 70's - Space Down to Earth. (Earth Applications of space Technology) NASA.

289. The Age of Space Transportation. NASA.

290. The First U.S. Space Walk. NASA.

291. Lunar Module Descent to the Moon. NASA.

292. First Steps to the Stars. (summary of early space flights) McDonnel Douglas.

293. The Lighthouse That Never Fails. (excellent comedy on space flight) Sperry Univac.

294. Hail Columbia. (First Shuttle Flight) NASA.

FILMSTRIPS

295. Meteorology From Space. NASA.

296. How an Astronaut Lives In Space. Filmstrip House.

297. Man in Space. (Walt Disney) . Encyclopedia Britannica Films, Inc.

Many other films and filmstrips can be found in the NASA film catalog. Catalogs are available from NASA Lewis Research Center (see page 262) and from the Aviation and Space Center, Oakland University, Rochester, MI 48063

298. COMMERCIAL TEXTBOOKS

Don't overlook these resources in your own classroom. Every effort was made to include lessons which correspond directly to the textbooks currently being used in the state. The following is an alphabetical list of those texts.

ACCENT ON SCIENCE k-6
Charles Merrill Publishing Co.
1300 Alum Creek Dr. P.O.Box 508
Columbus, OH 43216

ADDISON-WESLEY SCIENCE
Addison-Wesley
1843 Hicks Road
Rolling Meadows,IL 60008

CONCEPTS IN SCIENCE
Harcourt Brace Jovanovich, Inc.
7555 Caldwell Ave.
Chicago, IL 60648

GATEWAYS TO SCIENCE K-6
McGraw-Hill Book Company
1221 Avenue of the Americas
New York, NY 10020

HEATH SCIENCE K-6
D.C.Heath and Company
125 Spring Street
Lexington, MA 02173

HOUGHTON MIFFLIN SCIENCE 1-6
Houghton Mifflin
7055 Amwiler Industrial Dr.
Atlanta, GA 30360

SCIS, SCIIS, SCIS II & S-APA II
Delta Education Inc.
Bldg.4, Box M, Factory Street
Nashua,NH 03061

ADDRESSES OF AGENCIES SUPPLYING MEDIA LISTED IN THE RESOURCE SECTION

GOVERNMENT FILM AGENCIES

1. United States Air Force

Central Audio-Visual Library
Aerospace Audiovisual Service
Norton AFB,California 92409

Films available free on request. Request films three weeks in advance. Catalog available from the U.S. Gov't printing office.

2. Federal Aviation Administration (FAA)

Film Library, AAC-44E
Federal Aviation Administration
P.O. Box 25082
Oklahoma City, Oklahoma 73125

Films available free. Request two weeks in advance. Two films per week may be ordered. Write for catalog.

3. NASA - Lewis Research Center

Teacher Information Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, Ohio 44135 (216) 433-4000 ext. 6110

Free loan. Phone or write for current catalog and availability. NASA will copy films on to video format at your request for the cost of materials only.

4. Michigan Aeronautics Commission

Capital City Airport
Lansing, Michigan 48906

Write for film list. Free loan.

NON-GOVERNMENT FILM AGENCIES

1. Agency for Instructional Television
   Box 1111 West 17th Street
   Bloomington, IN 47401

2. American Association of Physics Teachers
   Graduate Physics Building
   SUNY at Stony Brook
   Stony Brook, NY 11794

3. Association-Sterling Films
   866 Third Avenue
   New York, NY 10022

4. Beech Aircraft Corporation
   Wichita, KS 67201

5. Business Aircraft Association
   425 13th St., N.W., Suite 401
   Washington, DC 20004

6. Champion Spark Plug Company
   Film Section, Department M
   P.O. Box 910
   Toledo, OH 43661

7. Coronet Films
   65 E. South Walter Street
   Coronet Building
   Chicago, IL 60601

8. Eastern Airlines, Inc.
   Film Library
   International Airport Branch
   Miami, FL 33148

9. Encyclopedia Britannica Educational Corporation
   1150 Wilmette Avenue
   Wilmette, IL 60091

10. General Aviation Manufacturers Association
Suite 1200-A, 1025 Connecticut Avenue, N.W.
Washington, DC 20035

11. Goodyear Tire and Rubber Company
Public Relations Film Library
1144 East Market Street
Akron, OH 44316

12. G.C. Burns Film Presentation
17160 Tulsa Street
Grenada Hills, CA 91340

13. Kitt Peak National Observatory
Films, Public Information Office
P.O. Box 26732
Tucson, AZ 85726

14. Lockheed-Georgia Company
Motion Picture Film Library
Zone 30, B-2 Building
Marietta, GA 30063

15. McDonnel Douglas Corporation
2525 Ocean Park Blvd.
Film Distribution and Promotion
Santa Monica, CA 90405

16. Modern Talking Picture Service, Inc.
21421 Hilltop St. Suite 23
P.O. Box 5022
Southfield, MI 48037

17. Shell Film Library
1433 Sadlier Circle W. Drive
Indianapolis, IN 46239

18. Society for Visual Eduction (Filmstrips)
Division of General Precision Equipment Corp.
1345 Diversey Parkway
Chicago, IL 60614

19. Sperry Univac
Advertising and Sales Promotion
P.O. Box 500
Blue Bell, PA 19422

20. Walt Disney Productions
Education Films Division
350 Buena Vista Avenue
Burbank, CA 91503

21. Western Airlines
P.O. Box 92005
World Way Postal Center
Los Angeles, CA 90009

GOVERNMENT PUBLICATIONS AGENCIES

1. Civil Air Patrol (CAP)

National Headquarters
Maxwell AFB, AL 36112

Michigan Wing (CAP)
30712 Michigan Ave.
Building A
Westland, MI 48184
(313) 721-6210

2. Federal Aviation Administration (FAA)

FAA Headquarters
Public Inquiry Center, APA-430
800 Independence Avenue, S.W.
Washington, D.C. 20591
(202) 426-8058/8059

Great Lakes Region, AGL-5
2300 East Devon Avenue
Des Plains, IL 60018
(312) 694-4500

3. National Aeronautics and Space Administration (NASA)

NASA Headquarters
Community and Education Services Branch
LFG-11
Washington,D.C. 20546

NASA Lewis Research Center
Teacher Resource Center
21000 Brookpark Road
Cleveland,OH 44135
(216) 433-4000 ext. 6110

4. State Government

Michigan State Aeronautics Commission
Capital City Airport
Lansing, MI 48906
(517) 373-1834

5. United States Government Printing Office

Gov't Printing Office
710 North Capital St.
Washington, DC 20230
9202) 275-2091

Patrick V. McNamara Federal Building
Suite 160
477 Michigan Avenue
Detroit,MI 48226
(313) 226-7816

NON-GOVERNMENT PUBLICATIONS AGENCIES

1. Aero Products Research, Inc.
11201 Hindry Avenue
Los Angeles, CA 90045

3. AVI Astroport
Mineral Point, WI 53565

3. Air Transport Association of America
Public Relations Department
1709 New York Avenue, N.W.
Washington, DC 20006

4. Alabama Space and Rocket Center
Tranquility Base
Huntsville, AL 35807

Request free teaching aids.

5. J.T. Becker Associates
799 Roosevelt Road
Glen Ellyn, IL 60137

6. Beech Aircraft Corporation
Wichita, KS 67201

7. Cessna Aircraft Company
Air Age Education Department
P.O. Box 1521
Wichita, KS 67201

8. Estes Industries
Penrose, CO 81240
(model rockets and education materials)

9. Flying Tiger Line
7401 World Way West
P.O. Box 92935
Los Angeles, CA 90009

10. General Aviation Manufactures Association
Suite 1215
1025 Connecticut Avenue, N.W.
Washington, DC 20036

11. Hamilton Standard
Windsor Locks, CN 06096

12. Jeppesen Sanderson
Education Division
8025 E. 40th Avenue
Denver, CO 80207

13. Kitt Peak National Observatory
Public Information Office
P.O. Box 26732
Tucson, AZ 85726

14. Lockheed, Lockheed-Georgia Company
86 South Cobb Drive
Marietta, GA 30063

15. Los Angeles Department of Airports
No. 1 World Way
Los Angeles, CA 90009
Attention: Public Relations Department

16. Ninety-Nines International Headquarters
P.O. Box 59964
Will Rogers World Airport
Oklahoma City, OK 73159

17. Young Readers Press
1 West 39th Street
New York, NY 10018

AEROSPACE EDUCATION CURRICULUM GUIDES

Aerospace Education at the Elementary Level (A collection of articles from the Journal of Aerospace Education)

American Society for Aerospace Education
1750 Pennsylvania Avenue,N.W.
Suite 1303
Washington, DC 20006

Aerospace Education Curriculum Guide

Indiana Dept. of Public Instruction
120 W. Market St.
Indianapolis, IN 46204

Aerospace Units for Elementary Classrooms

Aviation Education Office
Federal Aviation Administration
Department of Transportation
Washington, DC 20590

A Universe to Explore

National Science Teachers Association
1201 16th St. N.W.
Washington, DC 20036

Elementary School Aerospace Activities EP-147

NASA - Lewis Research Center
Teacher Resource Center
21000 Brookpark Road
Clevland, OH 44135

Falcon Force

Civil Air Patrol
National Headquarters CAP
Maxwell,AFB,AL 36112

An Introduction to Aerospace Education

New Horizons Publishers, Inc.
Chicago, IL

Aerospace Projects for the Elementary School

Jane A. Caballero, Ph.D.
University of Miami
Coral Gables, FL

High Flight an aerospace curriculum guide K-12

Oklahoma State Department of Education
Oklahoma City, OK

Tennessee Aerospace Education Curriculum Guide

Tennessee Department of Education
Building 309
11th Avenue
Smyrna, TN 37167

ADDITIONAL RESOURCE BOOKS

SPACE

Aerospace Industires Association of America
610 Shoreham Bldng.
Washington, DC

WHAT'S UP Probing the Natural World

I.S.C.S.
Silver Burdett
Park Ridge, IL

TEACHER BOOKS

ELEMENTARY SCHOOL SCIENCE and HOW TO TEACH IT
Holt, Rinehart and Winston
Chicago, IL

SCIENCE FOR CHILDREN
Prentice-Hall Inc.
Englewood Cliffs, NJ 07632

SCIENCE FOR THE ELEMENTARY SCHOOL
Macmillan Pub.Co., Inc.
866 Third Ave.
New York, NY 10022

TEACHING ELEMENTARY SCIENCE
Wadsworth Pub. Co., Inc.
Belmont, CA 94002

TEACHING SCIENCE AS CONTINUOUS INQUIRY
McGraw Hill, Inc
1221 Avenue of the Americas
NewYork, NY , 10020

THE EVERYDAY SCIENCE SOURCEBOOK
Allyn and Bacon, Inc.
470 Atlantic Ave.
Boston, MA 02210

RESOURCE CENTERS

The following are depositories of information related to Aerospace Education. Most have materials which can be used at the center but not checked out.(a notable exception is NASA). Contact each center for their current policies and procedures.

Central Michigan University
Dr. John Bergeson, Director
Instructional Materials Center
Rowe Hall
Mt. Pleasant, Michigan 48858

Macomb Community College
Prof. Earl Hickey
Warren, Michigan 48000

Michigan Space Center
Jackson Community College
2111 Emmons Road
Jackson, Michigan 49201 (517) 787-4425

Michigan State University
Dr. James Page
East Lansing, Michigan 48823

Oakland University
Aviation and Space Center
Rochester, Michigan 48063

Western Michigan University
Prof. Herman Linder
Kalamazoo, Michigan 49001

NASA - Lewis Resarch Center, Visitors Center
21000 Brookpark Road
Clevland, Ohio 44135 (216) 433-4000 Ext.6110

"SPACEMEN" WITH MICHIGAN CONNECTIONS

Several men with Michigan connections have been or are involved with the U.S. space program. Here are the biographies of a few of them:

ASTRONAUT JAMES A. MC DIVITT (USAF)

Born June 10, 1929, in Chicago, Illinois. The astronaut's mother, Mrs. James McDivitt, residesin JACKSON, MICHIGAN. He graduated from KALAMAZOO CENTRAL HIGH SCHOOL, KALAMAZOO, MICHIGAN and received a Bachelor of Science Degree in Aeronautical Engineering from the UNIVERSITY OF MICHIGAN in 1959 and an Honorary Doctorate in Astronautical Science in 1965. He was command pilot for Gemini 4, a 66-orbit, four day mission in June of 1965. During March of 1969, he was commander of Apollo 9, an earth orbital mission, which was the first demonstration of the entire set of Apollo flight hardware. In June of 1969, he left the astronaut office and became manager for Lunar Landing Operation in the Apolllo Spacecraft Office. In September of 1969, he became manager of the Apollo Spacecraft Program, with overall responsibility for the entire Apollo Spacecraft Program Office. Later, he was made Senior Vice President at Consumers Power Company in JACKSON, MICHIGAN.

ASTRONAUT ALFRED MERRILL WORDEN (USAF)

Born February 7, 1932, in JACKSON, MICHIGAN. His parents reside in JACKSON. Worden attended Dibble, Griswold, Bloomfield and East Jackson grade schools and completed his secondary education at JACKSON HIGH SCHOOL. He received a Bachelor of Military Science Degree from the United States Military Academy in 1955 and Master of Science Degrees in Astronautical/Aeronautical Engineering and Instrumentation Engineering from the UNIVERSITY OF MICHIGAN in 1963. He was awarded an Honorary Doctorate of Astronautical Science from the UNIVERSITY OF MICHIGAN in 1971. Worden served as a member of the astronaut support crew for the Apollo 9 flight and as backup command module pilot for the Apollo 12 flight. He served as command module pilot for Apollo 15, July 26 to August 7, 1971, the fourth manned lunar landing mission and the first to visit and explore the moon's Hadley Rille and Apennine Mountains.

ASTRONAUT JACK ROBERT LOUSMA (LT. COLONEL, USMC)

Born February 29, 1936, in GRAND RAPIDS, MICHIGAN. His father, Mr. Jacob Lousma, resides in JACKSON, MICHIGAN. He attended Tappan Junior High School and ANN ARBOR HIGH SCHOOL and received a Bachelor of Science Degree in Aeronautical Engineering from the UNIVERSITY OF MICHIGAN in 1959. He is married to the former Gratia Kay Smeltzer of Ann Arbor. Her mother, Mrs. Chester Smeltzer, resides in Bear Lake, Michigan. Lt. Colonel Lousma served as a member of the astronaut support crews for the Apollo 9, 10 and 13 missions. Lousma was pilot for Skylab-3, July 28 to September 25, 1973, with fellow crewmen Alan L. Bean and Owen K. Garriott. Skylab-3 completed 858 revolutions of the earth and traveled some

24,400,000 miles in earth orbit. Lousma was designated backup docking module pilot of the U.S. flight crew for the Apollo-Soyuz Test Project mission which was launched in July of 1975. In March, 1982, he commanded the 3rd Space Shuttle mission.

ASTRONAUT ROGER B. CHAFFEE

Born February 15, 1935, in GRAND RAPIDS, MICHIGAN, where his parents, Mr. and Mrs. Donald Chaffee reside. Chaffee, now deceased, graduated from CENTRAL HIGH SCHOOL, GRAND RAPIDS, MICHIGAN, and received a Bachelor of Science Degree in Aeronautical Engineering from Purdue University in 1957. He was awarded the Navy Air Medal.

ASTRONAUT CAPT. THEODORE C. FREEMAN (USAF)

Born February 18, 1930, in Edwards, California. In 1960, he received a Master of Science Degree in Aeronautical Engineering from the UNIVERSITY OF MICHIGAN. Astronaut Freeman, who was a member of the American Institute of Aeronautics and Astronautics, died in the crash of a T-38 aircraft on October 31, 1964, at Ellington Air Force Base, Houston, Texas.

ASTRONAUT EDWARD H. WHITE II (USAF)

Born November 14, 1930, in San Antonio, Texas. He received a Master of Science Degree in Aeronautical Engineering from the UNIVERSITY OF MICHIGAN in 1959 and an Honorary Doctorate in Astronautics from the UNIVERSITY OF MICHIGAN in 1965. He has received many awards, including the Air Force Commendation Medal, the NASA Exceptional Service Medal and the Air Force Astronaut Wings, and was selected as one of the Ten Outstanding Young Men of America for 1965. Lt. Colonel White was selected as an astronaut by NASA in September of 1962. He was pilot for Gemini 4, a 62-revolution four-day mission that began on June 3 and ended June 7. During the third revolution he performed the first extra-vehicular activity in the U.S. manned space flight program. He was outside the spacecraft for a period of 23 minutes and became the first man to maneuver himself in an extra-vehicular space environment with a hand-held maneuvering unit. Lt. Colonel White, who is now deceased, was named senior pilot for the first flight of the three-man Apollo series.

ASTRONAUT FRED WALLACE HAISE, JR

Born November 14, 1933, in Biloxi, Mississippi. He received an Honorary Doctorate of Science from WESTERN MICHIGAN UNIVERSITY in 1970. He has received numerous awards and published several papers on aircraft. Mr. Haise is one of the 19 astronauts selected by NASA in April of 1966. He served as backup lunar module pilot for the Apollo VIII and XI missions and was lunar module pilot for Apollo XIII in April of 1970, with fellow crewmen James A. Lovell and John L. Swigert. He was later designated to serve as backup spacecraft commander for the Apollo XVI mission.

ASTRONAUT KARL G. HENIZE (PH D)

Born October 17, 1926, in Cincinnati, Ohio. He was awarded a Ph D in Astronomy in 1954 by the UNIVERSITY OF MICHIGAN and is married to the former Caroline Weber of BAY CITY, MICHIGAN. Her mother and stepfather, Mr. and Mrs. Martin Urban, reside in BAY CITY. Dr. Henize was an observer for the UNIVERSITY OF MICHIGAN OBSERVATORY from 1948 to 1951, stationed at the Lamont-Russey Observatory in Bloemfontein, Union of South Africa. Dr. Henize was selected as a scientist-astronaut by NASA in August of 1967. He was a member of the astronaut support crew for the Apollo 15 mission and is serving in this capacity for the ongoing Skylab flights.

ASTRONAUT JAMES BENSON IRWIN (COLONEL, USAF)

Born March 17, 1930, in Pittsburgh, Pennsylvania. He received Master of Science Degrees in Aeronautical Engineering and Instrumentation Engineering from the UNIVERSITY OF MICHIGAN in 1957 and was awarded an Honorary Doctorate of Astronautical Science from there in 1971, with fellow crewmen David R. Scott and Alfred M. Worden. Apollo 15 was the fourth manned lunar landing mission and the first to visit and explore the moon's Hadley Rille and Apennine Mountains. Irwin and Scott, using "Rover-1" to transport themselves and their equipment, collected approximately 160 pounds of lunar surface materials. Their lunar surface activities were televised in color using a TV camera which was operated remotely by ground controllers stationed in the mission control center in Houston, Texas.

ASTRONAUT JOHN LEONARD SWIGERT, JR

Born August 30, 1931 in Denver, Colorado. He received an Honorary Doctorate of Science from WESTERN MICHIGAN UNIVERSITY in 1970. He served as a member of the astronaut support crew for the Apollo VII flight and was assigned to the Apollo XIII backup crew and subsequently was called upon to replace prime crewman Thomas K. Mattingly as command module pilot. The original flight plan for Apollo XIII, April 11 to 17, 1970, was modified enroute to the moon due to a failure of the service module cryogenic oxygen system which occured approximately 55 hours into the flight. The astronaut died in December of 1982, at age 51, after being elected to Congress in Colorado.

ASTRONAUT EDGAR DEAN MITCHELL (USN)

Born September 17, 1930, in Hereford, Texas. He is married to the former Louise Elizabeth Randall of MUSKEGON, MICHIGAN. He served as a member of the astronaut support crew for Apollo IX and as backup lunar module pilot for Apollo X. He completed his first space flight as lunar module pilot on Apollo XIV, January 31 to February 9, 1971. Maneuvering their lunar module "Antares" to a landing in the hilly upland Fra Mauro region of the moon, Mitchell and fellow crewman Alan B. Shepard subsequently deployed and activated various scientific equipment and experiments and collected almost 100 pounds of lunar samples for return to earth. Mitchell was subsequently designated to serve as backup lunar module pilot for Apollo XVI.

ASTRONAUT DAVID R. SCOTT (USAF)

Born June 6, 1932, in San Antonio, Texas. He earned an Honorary Doctorate of Astronautical Science from the UNIVERSITY OF MICHIGAN in 1971. On March 16, 1966, he and command pilot Neil Armstrong were launched into space on the Gemini 8 mission, a flight originally scheduled to last three days but terminated early due to a malfunctioning thruster. Scott served as command module pilot for Apollo 9, March 3 to 13, 1969. He made his third space flight as spacecraft commander of Apollo 15, July 26 to August 7, 1971. Scott's performance ranks him in second place in the individual standings for total space flight time accrued by America's astronauts.

ASTRONAUT DONALD K. SLAYTON

Born March 1, 1924, in Sparta, Wisconsin. He received an Honorary Doctorate in Engineering from MICHIGAN TECHNOLOGICAL UNIVERSITY, HOUGHTON, MICHIGAN, in 1965. He was named as one of the Mercury astronauts in April 1959. He was originally scheduled to pilot the Mercury-Atlas 7 mission but was relieved of his assignment due to a heart condition discovered in August. Slayton became coordinator of Astronaut Activities in September of 1962 and was responsible for the operation of the astronaut office. In November of 1963, he resigned his commission as an Air Force Major to assume the role of Director of Flight Crew Operations. In March of 1972, following a comprehensive review of his medical status by NASA's Director of Life Sciences and the Federal Aviation Agency, Slayton was restored to full flight status and certified eligible for future manned space flights. He was named to the U.S. flight crew for the Apollo-Soyuz Test Project mission launched in July of 1975.

ASTRONAUT NAVY CAPTAIN ALAN BEAN

Astronaut Bean, whose parents grew up in JACKSON (he still has relatives there), was a member of the backup crew of Gemini 10 and was designated Lunar Module Pilot for Apollo 12, during which time he participated in two lunar walks. He was backup spacecraft commander for the joint Apollo-Soyuz Test Project mission and headed the astronaut-candidate operations and training group after his Navy retirement.

ASTRONAUT CAPTAIN RICHARD POLLARD

Born in JACKSON in 1920. He has been administrator of NASA launch bases. He also was Special Assistant to the Associate Administrator for Manned Space Flight, where he was instrumental in working out an agreement between NASA and the European Space Research Organization for the sharing of costs for space ventures. He now is in charge of advance mission programs for beyond 1980. He was graduated from JACKSON HIGH SCHOOL and JACKSON JUNIOR COLLEGE, received a Bachelor of Science in Aeronautical Engineering from the UNIVERSITY OF MICHIGAN and a Master of Science Degree from the MICHIGAN INSTITUTE OF TECHNOLOGY. He is credited with being one of the fathers of the Polaris missile program. His brother-in-law, J. Adrian Rosenburg, a niece, and several cousins reside in JACKSON.

DOUGLAS AHRENS

Mr. Ahrens, a 1947 graduate of JACKSON HIGH SCHOOL, was the General Dynamics Astronautics Leading Propulsion Engineer for Complex 14, Mercury launching site at Cape Kennedy. He was also connected with the Gemini series. It was his job to erect the missile, check out the engineering before the flight and make sure everything was "A-OK" during the initial lift-off period.

ASTRONAUT BREWSTER SHAW USAF

Born May 16, 1945 in Cass City, Michigan. He graduated from Cass City High School in 1963. He earned a Bachelor of Science and Masters Degrees from the University of Wisconsin. He was a highly decorated pilot while in the Air Force earning the Distinquished Flying Cross as well as many other medals and honors. He was a Distiquished Graduate at the Officers Training School and the Air Force Test Pilots School. He logged over 3000 hours of flight time in 30 types of aircraft while in the Air Force. He became an astronaut in 1979 and flew as pilot on Shuttle 9.

---contributed by Michigan Space Center
Jackson Community College
Jackson, Michigan

GLOSSARY

ablation:	the vaporization of an outer covering (as of a spacecraft) to keep the inner part cool
abort:	to cut short (an action or operation of an aircraft, guided missile, etc.), because of some failure in the equipment
aerobatics:	performance of stunts in an airplane or glider
aerodynamics:	the science that treats the motion of air and other gaseous fluids, and of the forces acting on bodies when the bodies move through such fluids, or when such fluids move against or around the bodies
aeronautics:	the science, art, or work of designing, making and operating aircraft
aerospace:	the earth's atmosphere and the space beyond
aileron:	a movable hinged section in or near the trailing edge of an airplane wing for controlling the rolling movements and turns of the airplane
aircraft:	a weight-carrying machine for navigation of the air that is supported either by its own buoyancy or by the action of the air against its surface
airfoil:	a part with a flat or curved surface, as a wing, rudder, etc., designed to keep an aircraft up or control its movements by reacting in certain specific ways to the air through which it moves
airship:	any self-propelled aircraft that is lighter than air and can be steered; dirigible
airspeed:	the speed of an aircraft relative to the air through which it moves rather than to the ground

altimeter:	an instrument for indicating the relative altitude of an airplane by measuring atmospheric pressure
altitude:	height; esp., the height of a thing above the earth's surface
animometer:	a device for measuring the velocity of the wind, in common use at airports
apogee:	the point farthest from the earth in the orbit of the moon or of a man-made satellite
Apollo:	United States program with the objective of earth-orbiting a space laboratory, launching astronauts to the vicinity of the moon, and landing a man on the moon, then returning him to earth
astro:	a prefix meaning "star" or "stars" and, by extension, sometimes used as the equivalent of "celestial," as in astronautics
atmosphere:	the earth's blanket of air, dust and water vapor extending from the earth's surface to possibly as far as 50,000 miles
azimuth:	the initial angle or direction between true North and a great circle course
balloon:	an airtight bag filled with heated air or with a gas lighter than air so as to rise and float above the ground
bank:	to incline an airplane laterally when turning
barometric pressure:	the pressure of the atmosphere as indicated by a barometer
beacon:	a signal light or radio transmitter emitting signals for guidance of airplanes
Bernoulli's principle:	as the speed of a confined fluid increases, the fluid pressure decreases
bioastronautics:	aeronautics considered for its effect upon animal or plant life
biplane:	an airplane with two main supporting surfaces usually placed one above the other

blimp:	a small balloon-shaped airship
boosters:	the first stage of a multi stage rocket providing thrust for the launching and the initial part of the flight
capsule:	a small pressurized compartment for an aviator or astronaut for flight or emergency escape
ceiling:	the greatest height at which an airplane can maintain level flight or operate efficiently
Celsius:	centigrade; on this thermometer scale, water boils at 100 and freezes at 0 degrees
center of gravity:	the point through which the resultant forces of gravity acts no matter how the body is oriented
centrifugal force:	the force that tends to impel a thing or parts of a thing outward from a center
cloud types:	See page 113
cockpit:	a space in the fuselage of an airplane for the pilot or the pilot and passengers or in a large passenger plane, the pilot's crew
constellation:	any of 88 groups of stars forming patterns (as the Great Bear) or an area of the heavens covering one of these groups
contact:	direct visual observation of the earth's surface made from an airplane, esp., as an aid to navigation
drag:	the retarding force acting on a body (as an airplane) moving through a fluid (as air) parallel and opposite to the direction of motion
elevator:	a moveable airfoil usually attached to the tail plane of an airplane for producing motion up or down
escape velocity:	the minimum velocity that a moving body (as a rocket) must have to escape from the gravitational field of the earth or of a celestial body and move outward into space

exosphere:	the outer fringe region of the atmosphere
FAA:	Federal Aeronautics Administration
Fahrenheit:	relating or conforming to a thermometric scale on which under standard atmospheric pressure, the boiling point of water is at 212 degrees above the zero of the scale and the freezing point is at 32 degrees above zero
flaps:	moveable sections of the plane's wing that allow the plane to slow
flight line:	a parking and servicing area for airplanes
flight path:	the path of the center of gravity of an airplane in flight
flight plan:	specified information relating to the intended flight of an aircraft that is filed orally or in writing with an air traffic control facility
front (weather):	the boundary between two different air masses
fuselage:	the main structure or central section of an airplane which houses or contains the crew, passengers, cargo, etc.
glide:	sustained forward flight in which speed is maintained only by the loss of altitude
glider:	a heavier-than-air aircraft, the free-flight of which does not depend upon a power-generating unit
gravity:	the force of attraction between two bodies; the force that makes a body, if free to move, accelerate toward the center of the earth
ground speed:	the speed of the aircraft relative to the ground
ground visibility:	prevailing horizontal visibility near the earth's surface as reported by the National Weather Service or an accredited observer
haze:	fine dust or salt particles scattered through a portion of the atmosphere

heading:	the direction in which the nose of the airplane points during flight
helicopter:	a type of rotorcraft, the support of which in the air, is normally derived from airfoils mechanically rotated about an approximately vertical axis
horizontal stabilizer:	the level surface of the rear part of the fuselage used to balance the plane
humidity:	the measure of water vapor content in the air
hypoxia:	oxygen deficiency in blood cells or tissue
inertia:	the tendency of a body to remain as it is, either at rest or in motion, until acted upon by some outside force
IFR:	instrument flight rules
lift:	the force on an airfoil, perpendicular to the relative wind, exerted normally upward, opposing the pull of gravity
magnetic deviation:	see Variation
monoplane:	an airplane having one lifting surface
NASA:	National Aeronautics and Space Administration
orbit:	to send up and make revolve in an orbit (orbit a satellite)
pitch:	the blade angle of a propeller
propeller:	a rotating blade on the wing or fuselage of a plane
reentry:	the action of reentering the earth's atmosphere after travel in space
roll:	the movement of a plane on an axis running from the the front to the rear of the plane
rudder:	the moveable, vertical section of the tail which controls lateral, left/right movement
runway:	a strip, either paved or improved, on which takeoffs and landings are effected
satellite:	a person-made object or vehicle intended to orbit the earth, the moon, or another celestial body

solar system:	the sun and the planets, asteroids, comets and meteors that revolve around it
sonic boom:	a noise caused by a shock wave that emanates from an aircraft or other object traveling at or above the speed of sound
sounding balloon:	a free, unmanned balloon instrumented and/or observed for obtaining a sounding of the atmosphere
spin:	a prolonged stall in which an airplane rotates about its center of gravity while it descends
spiral:	a prolonged gliding or climbing turn during which at least 360° change of direction is effected
stability:	the tendency of an airplane in flight to remain in straight, level, upright flight
stabilizer:	the fixed airfoil of an airplane used to increase stability
stall:	the flight maneuver or condition in which the air passes over and under the wings' stops, providing lift to hold the aircraft's attitude
standard temperature:	a temperature decrease of approximately 2° Celsius for each 1,000 feet increase in altitude; also called the adiabatic rate
statute mile:	5,280 feet or 0.867 nautical miles
stratosphere:	an atmospheric layer at heights of approximately 20 to 30 miles characterized by high ozone content
supercharger:	a pump or compressor for forcing more air or fuel-air mixture into an internal combusion, reciprocating engine than it would normally induct at the prevailing density altitude
thrust:	the forward force on an airplane in the air, provided by the engine
torque:	any turning or twisting force
track:	the flight path made good over the ground by an aircraft

traffic pattern:	the traffic flow that is prescribed for aircraft landing at, taxiing on, and taking off from an airport
troposphere:	the layer of the atmosphere nearest to the earth; contains 75% of the gases of the atmosphere as well as dust and water; layer where weather occurs; extends upwards approximately 20 miles
true altitude:	the altitude above mean sea level
turbulence:	irregular motion of the atmosphere produced when air flows over a comparatively uneven surface
variation:	the angle difference at a given point between true north and magnetic north
vertigo:	sensory confusion, usually associated with dizziness and inability to tell which way is up
visibility:	in weather observing practice, the greatest distance in a given direction at which it is possible to see and identify with the unaided eye
visual flight rules (VFR):	when weather conditions are above the minimums prescribed for visual meteorological conditions, pilots may fly with visual reference to the ground
wake turbulence:	the turbulence caused by a moving aircraft
wind sock:	a cloth sleeve, mounted aloft at an airport to use for estimating wind direction and velocity
wind tee:	an indicator of wind direction for takeoff and landing
wing:	an airfoil whose major function is to provide lift
wing flap:	a movable section of an airfoil used to change the effect of air flow over the airfoil
yaw:	to turn about the vertical axis
Zulu time:	Universal time: local civil time in Greenwich, England; used throughout the world in navigation

---taken, in part, from:
"High Flight" Aerospace Activitie
Oklahoma State Dept of Education

ADDENDUM

Just prior to publication, several more books were cataloged and sent to the Aviation and Space Resource Center located in the Resource Center at Oakland University. The following addendum lists those resources.

WEATHER

TEACHER BOOKS

299. Field Guide to the Atmosphere. Houghton Miflin.

300. Ludlum, David. The American Weather Book. Houghton Miflin, 1982.

THE EARTH AND THE SOLAR SYSTEM

TEACHER BOOKS

301. Pasikov. Field Guide to the Stars and Planets. 2nd ed. Houghton Miflin, 1983.

302. The New Solar System. 2nd ed. Sky Publishing.

303. Sky Guide. Golden Press, 1982.

304. Branley, Franklyn. The Planets in Our Solar System. Crowell, 1981.

305. Branley, Franklyn. Saturn - The Spectacular Planet. Crowell, 1983.

306. Branley, Franklyn. The Sky is Full of Stars. Crowell, 1981.

307. Ford, Adam. Space Ship Earth. Lothrop, Lee and Shepard Books, 1981.

308. Gallant, Roy A. The Planets: Explaining the Solar System. Four Winds Press, 1982.

309. Knight, David. The Moons of Our Solar System. William Morrow and Co., 1980.

310. Kraske, Robert. Riddles of the Stars. Harcourt Brace Jovanovich, 1979.

311. Zin, Herbert. The New Moon. William Morrow and Co., 1980.

ROCKETS

STUDENT BOOKS

312. Olney, Ross R. Out to Launch: Model Rockets. Lothrop, Lee and Shepard Books, 1979.

SATELLITES, SPACE CRAFT AND SPACE TRAVEL

STUDENT BOOKS

313. Taylor, Paula. The Kids' Whole Future Catalog. Random House, 1982.

314. Zaffo, George J. The Giant Book of Things in Space. Doubleday, 1969.

THINGS THAT FLY

STUDENT BOOKS

315. Aron, Jon and Linsley, Leslie. Air Crafts: Playthings to Make and Fly. Lodestar Books, E. P. Dutton, 1982.

316. Rosenblum, Richard. Wings: The Early Years of Aviation. Four Winds Press, 1980.

317. Scarry, Huck. Balloon Trip: a sketch book. Prentice Hall, 1982.

318. Zisfein, Melvin B. Flight - A Panorama of Aviation. Pantheon Books, 1981.

AEROSPACE EDUCATION RESOURCE PERSONS FOR TEACHERS

The following people from the state may be contacted by teachers for assistance related to aerospace education. Teachers are encouraged to contact those persons in their area in order to gain further information on the area of expertise of each individual.

Anglin, Mary, 301 S. Meade, Flint, MI 48503, (0) 313/235-0681;
313/238-2978

Armstrong, Dick, 22912 Canterbury Dr., St. Clair Shores, MI 48080;
313/776-7587

Beers, June, 1989 Mapleridge Rd., Rochester, MI 48063; 313/583-5435

Bennett, Esther, 46 Williams, Pontiac, MI 48053; 313/338-3376;
(0) 313/666-3555

Bergeson, Dr. John, Central Michigan University, Ronan Hall, Mt. Pleasant,
MI 48859; (0) 517/774-3549 AECM

Berz, Ted, 46284 Johnathan Circle, Utica, MI 48087; 313/739-0632

Binsfield, Addie, 3843 Island Park Dr., Drayton Plains, MI 48020;
313/674-4453

Bobrowicz, Dot, 34473 Grove Dr., Livonia, MI 48154; 313/591-1329

Bodrie, Shirley, 86 Chestnut, River Rouge, MI 48218; 313/843-8870

Boehmer, Capt. Curtis, Civil Air Patrol, 1445 Lakeside, P.O. Box 45,
Harbor Beach, MI 48441

Bonnell, Robert, Teacher, 6th Grade, Lincoln Park School, 3426 Leon,
Muskegon, MI 49441; (0) 616/755-1257; 616/798-2493 AECM

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Broome, Judith, 797 Lincoln Rd., Grosse Pointe, MI 48230; 313/882-4664; (0) 876-6126

Brown, John, 21975 Leyte, Farmington Hills, MI 48024; 313/474-4816

Bytwerk, Betty, 15780 Bittersweet, Spring Lake, MI 49456; 616/842-2646

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Clark, Ruth, 4931 Jewell, Howell, MI 48843; 517/546-0882

Collier, Dr. Calhoun, Retired Professor, Michigan State University, 612 Oakwood Dr., East Lansing, MI 48823; 517/332-2087 AECM

Conrad, Catherine Bennett ("Tip"), 2322 El Dorado S.E., Grand Rapids, MI 49506; (O) 364-9485, 616/942-9843

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Cook, Lynn, 140 W. Brown St., Tecumseh, MI 49286; (O) 517/423-7427; 517/423-4825

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DeForest, Lynn, 10519 Turnerwood Dr., Fenton, MI 48430; 517/546-2160

Del Giorno, Velma B., 10307 Blue Lake Rd., Mecosta, MI 49332; 616/972-7674

Dellinger, Rick, Director, Aviation Technology, Jackson Community College, 2111 Emmons Rd., Jackson, MI 49201; 517/787-0800

Devlin, Shiela, Birmingham, MI; 313/851-1963

Disler, Edith A., 6930 W. Dartmoor, W. Bloomfield, MI 48033; 313/855-2135

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Emery, Sister Marie T., 3142 Lake Lansing Road, East Lansing, MI 48823;
517/353-1790

Evans, Elaine, 760 Rachelle, Union Lake, MI 48045; 313/363-7902

Featherston, Frederick, 2955 Lynn, Pontiac, MI 48054; 313/666-2135

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School District; 630 Harvey, Muskegon, MI 49442; (O) 616/777-2637;
842-4317 AECM

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French, Tim, 1613 Vernon St., Trenton, MI 48183; 313/675-9075

Gardanier, Mary W., 1828 Miles Avenue, Kalamazoo, MI 49001; (O) 616/343-
1261, 616/344-0563

Greenlee, Eloise, Greenlee Printing Company, 423 Pine St., Calumet, MI 49913;
616/227-1300 AECM

Hecksel, Warren-Nancy, 2611 Greenway, Royal Oak, MI 48073; 313/576-0463

Hemingway Ilene, 15230 Lakewide Dr., Plymouth, MI 48170; 313/420-2973

Higgins, Leah, 4921 Crooks Rd., Apt. #N8, Royal Oak, MI 48073

Hoffman, Betsy Kay, 3297 E. Greenfield Court, Bay City, MI; (O) 754-2471;
684-4858

Housel, Dr. David, Science Professor, Oakland University, Rochester, MI 48063; (0) 313/377-3079, 348-7115 AECM

Housel, Doreen, Graphic Artist/Teacher, 19923 Schoolhouse Court, Northville, MI 48167; 313/348-7115 AECM

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Kreeger, Natalie Ruth, Director of Services, Fowlerville Public Schools, Fowlerville, MI 48836; (0) 223-8754, 223-9702 AECM

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48075; 313/357-5600

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Nicholsen, Valerie, 4850 Lodewyk, Detroit, MI 48224

Ojala, Claire, 26695 Simone, Dearborn Heights, MI 48127; 313/274-5674

Palka, Ed, 3358 Westwind Dr., Detroit, MI

Pailthorpe, Bill & June, 9536 Fenhill Dr., Grand Blanc, MI 48439; 313/
655-4019

Paulson, Col, Robert W., Wing Commander, Civil Air Patrol, 236 No. Lafayette,
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526-0846

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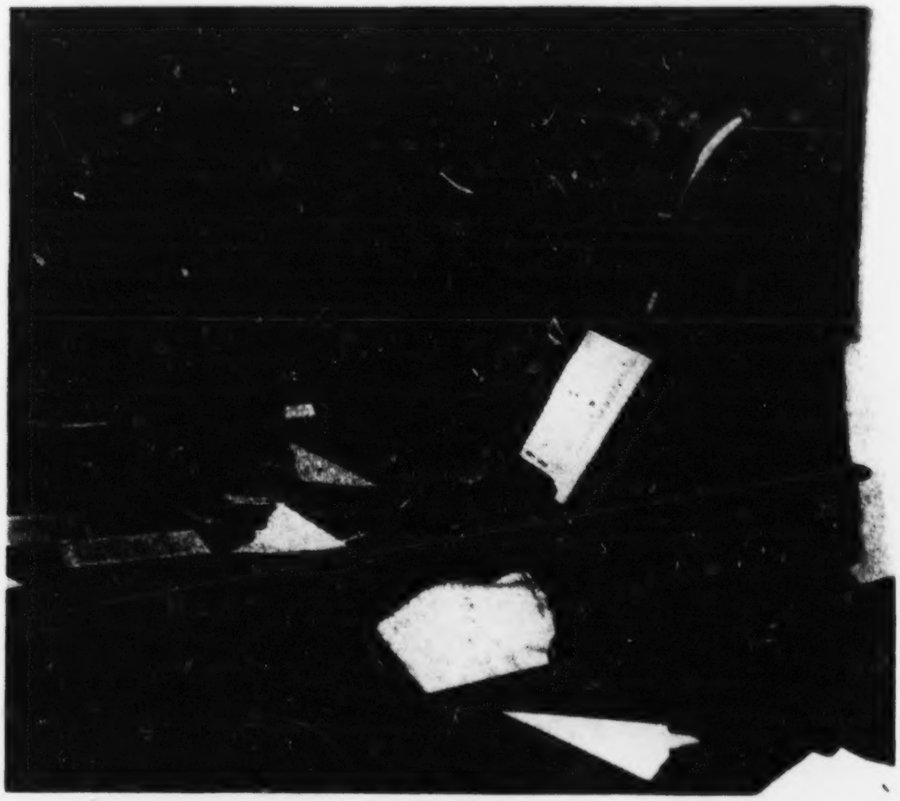
*AECM denotes Aerospace Education Council of Michigan members



Authors David and Doreen Housel, extreme right, present Come Fly With Me in draft form to Michigan teachers at a workshop in January, 1983. Sponsored by the Aerospace Education Council, the Lake Michigan Chapter of the Ninety-Nines, Lansing Community College (LCC), and endorsed by the Department of Education, the workshop was held at LCC's Aviation Technology facility at Capital City Airport, Lansing.

ABOUT THE AUTHORS

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David Charles Housel, co-author, was born in Green Bay, Wisconsin on April 9, 1941, and spent his elementary education years in Ashland, Oregon; Lansing, Michigan; and Glenshaw, Pennsylvania. Graduating in 1959 from the Shaler, Pennsylvania high school, he returned to Oregon to study science and education at Southern Oregon College in Ashland. The year, 1967-68 was spent earning his commercial pilot's license from the Sierra Academy of Aeronautics and attending California State University at Hayward. He entered Arizona State University in 1968, graduating in 1970 with a Bachelor of Arts degree in Elementary Education. While teaching elementary school in Phoenix (1970-73), he continued graduate study at Arizona State, earning a Master of Arts degree in Science Education in 1974. He was a Graduate Teaching Assistant and Instructor at Arizona State University (1974-78) while studying for his Doctor of Philosophy degree which was granted in August, 1982. Since 1978, he has been an Assistant Professor of Education at Oakland University in Rochester, Michigan.

DOREEN HOUSEL

Doreen Housel, co-author and illustrator, was born in Bay City, Michigan on March 30, 1939. After elementary education and high school in Unionville, Michigan, she studied first at Michigan State University and then at Wayne State University, graduating with a degree in English and Speech Education. After a move to Connecticut in 1970, she taught high school English in Stratford and, later, Advanced Expository Writing at the University of Bridgeport. Continuing her graduate studies there, she received a Master of Arts degree in Counseling in 1978. Since 1981 she has taught at Oakland University as an Adjunct Professor, assisting with the educational television program, "Open Math." Presently she is a university supervisor for student teaching at Oakland University in Rochester, Michigan.